CENTAUR COST, SCHEDULE AND PERFORMANCE REVIEW

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

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CENTAUR COST, SCHEDULE AND PERFORMANCE REVIEW

TUESDAY, MAY 21, 1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to call, at 2:07 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. NELSON. The committee will come to order.

Today is the first of 2 days of hearings to review the cost, schedule, and performance status of the Shuttle/Centaur Program.

In addition to an overview in a general way of these areas, we will particularly focus on the extent of, and the reasons for, the current cost overrun that is rather extraordinary that is being experienced by this program, overruns to the tune of, original estimates, $30 to $40 million for the program, now exceeding $100 million.

That is three or four times.

When this program was initiated several years ago, NASA assured us that it was a well-defined, and it was a low-risk venture. It is now clear that that assessment was, to say the least, overly optimistic.

Mistakes have been made in this program. Our intent is to find out what they are, and whenever possible, to determine what changes in management policies and procedures could prevent their reoccurrence on other programs in the future.

The principal witnesses today will be Jim Beggs, NASA's very capable Administrator. He will be accompanied by Jess Moore, Associate Administrator in the Office of Space Flight; Andy Stofan, the director of NASA's Lewis Research Center; and Larry Ross, the director of Space Flight Systems at Lewis.

Now, let me say that the biggest issue before the Congress today is not the Centaur overruns. The biggest issue before the Congress today is where I have just been, which is the Rules Committee, on what is going to be made in order on a budget.

I happen to know something about budgets, and at some point, if we don't have a member to assume the Chair for me, we are going to have to recess, because I am testifying to the Rules Committee for a substitute hard freeze, across the board, in addition to other substitutes that are being considered by the Rules Committee.

It has been my statement over time that if the budgetary process in the freeze movement did hold together that NASA was going to have to take its part. Four weeks ago, I ventured an opinion that it was likely that that budgetary process of something akin to across-the-board freeze was going to unravel.

That is not my opinion today. With the basis of what the Senate has done, now with the House Budget Committee product, and with a chance that substitutes such as mine or the Leath package may pass, it is very likely that the conference committee on the budget between the House and Senate are going to come out to something akin to the across-the-board freeze concept, in which case, NASA, in both the Senate and the House version, are held at the function 250, which is Science and Technology, at a level of $9.1 billion, which translates to NASA, basically the 1985 figure freeze.

And that is part of the reality of what we are dealing with. And when you experience cost overruns in Centaur, that just makes the very admirable and capable job that Administrator Beggs has been doing all the more difficult for him personally.

Now, I had a hand in it, Mr. Administrator, I can tell you that, personally between me and a few other members, we got the House Budget Committee back up to the same figure for NASA as is in the Senate level.

They were working on some mistaken information from CBO, and they had it 300 million below, and so at least we are looking from the position of the 1985 freeze level.

And whether or not that is going to be able to be increased down the line is still an open question, but I say that each day that goes by, my opinion increasingly becomes that this budgetary process is going to hang together, and it is not going to unravel, and you have heard me, even as one of NASA's chief proponents on this Hill, say that that is clearly in the interest of the country, that we do have a severe reduction in that deficit to keep us from going into the economic turmoil that we could experience.

So, in light of that, I would like us to approach this particular hearing recognizing that we have just got to be careful of what all is going on and to bring to light what you all have done, what you have identified as the problems, how it is going to be corrected, and so forth.

Mr. Walker has a statement for the record, and were he to be here, and he is on the floor at this particular point, were he to be here right at this moment, he would offer his opening comments, and we will enter this as part of the record, without objection.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT FOR
HONORABLE ROBERT S. WALKER
SHUTTLE CENTAUR COST OVERRUN HEARING
MAY 21, 1985

GOOD AFTERNOON, MR. CHAIRMAN. TODAY WE OPEN THE FIRST OF TWO DAYS OF HEARINGS ON THE OVERRUN WHICH HAS DEVELOPED IN THE SHUTTLE CENTAUR PROGRAM. THESE HEARINGS WILL GIVE US AN EXCELLENT CASE HISTORY OF AN OVERRUN WITH MULTIPLE CAUSES. IT APPEARS FROM THE INVESTIGATION THAT THIS COMMITTEE HAS CONDUCTED SO FAR, THAT WE WILL SEE THE RESULTS OF GOVERNMENTAL INDECISION, CONTRACTING DELAYS CAUSED BY THE CONTRACTING PROCESS, SCHEDULE PRESSURES DRIVEN BY SPECIFIC LAUNCH WINDOWS, AND BREAKDOWNS OF BOTH THE ENGINEERING AND MANAGEMENT SYSTEMS OF THE AGENCY AND THE CONTRACTOR.

OUR PURPOSE HERE TODAY IS NOT TO POINT THE FINGER OF BLAME, NOR TO ASSESS LIABILITY FOR A FAILED PROGRAM. IN FACT, THE SHUTTLE CENTAUR PROGRAM APPEARS TO BE A SUCCESS STORY IN MANY WAYS. THE FLIGHT HARDWARE IS WELL ALONG IN THE CONSTRUCTION PHASE, AND WE FULLY EXPECT THAT IT WILL BE DELIVERED TO CAPE CANAVERAL WELL IN ADVANCE OF THE ORIGINAL SCHEDULE.

THE COMMITTEE ON SCIENCE AND TECHNOLOGY IS CONCERNED THAT THERE HAVE BEEN SEVERAL PROBLEMS WITH THIS PROGRAM WHICH COULD HAVE BEEN VERY SERIOUS. WE WANT TO EXAMINE THOSE PROBLEMS SO THAT WE, AND NASA, WILL UNDERSTAND THEM BETTER, AND SO THAT THE

LESSONS LEARNED FROM THE SHUTTLE CENTAUR EXPERIENCE WILL BECOME A PART OF THE INSTITUTIONAL KNOWLEDGE BASE WITHIN THE AGENCY.

LET ME TAKE A MOMENT TO BRIEFLY SKETCH THE BACKGROUND OF THIS PROGRAM. IN THE SPRING OF 1981, THE COMMITTEE ON SCIENCE AND TECHNOLOGY REQUESTED A JOINT DOD AND NASA STUDY OF UPPER STAGE REQUIREMENTS FOR THE SHUTTLE ERA. IN NOVEMBER OF 1981, WE WERE TOLD THAT THE RESULT OF THAT JOINT STUDY WAS THAT BOTH DOD AND NASA AGREED THAT THE AIR FORCE SHOULD DEVELOP THE IUS AND NASA SHOULD DEVELOP SHUTTLE CENTAUR.

WE WILL DISCUSS THE SERIES OF LETTER CONTRACTS, MODIFICATIONS, CHANGES, CONTRACT STARTS AND STOPS WHICH FINALLY CULMINATED IN A DEFINITIZED CONTRACT FOR BOTH THE G AND THE G-PRIME VEHICLES IN FEBRUARY OF 1984. SINCE THE G-PRIME VEHICLES MUST BE AVAILABLE FOR THE LAUNCHES OF THE GALILEO MISSION TO JUPITER AND THE INTERNATIONAL SOLAR POLAR MISSION, WHICH HAS BEEN RENAMED ULYSSES, AND SINCE BOTH LAUNCHES MUST GO WITHIN ONLY A FEW DAYS OF EACH OTHER IN MAY OF NEXT YEAR, THERE HAVE BEEN SIGNIFICANT SCHEDULE PRESSURES TO HAVE THE VEHICLES READY ON TIME.

WE SEE SEVERAL PROBLEMS WHICH HAVE HELPED TO PROVIDE A CLIMATE IN WHICH AN OVERRUN COULD DEVELOP AND FLOURISH. THE FIRST OF THESE SEEMS TO HAVE BEEN AN OVERLY OPTIMISTIC VIEW OF THE SIMPLICITY OF DEVELOPING THE SHUTTLE CENTAUR AS A DRIVATIVE OF THE HIGHLY SUCCESSFUL ATLAS CENTAUR PROGRAM. THIS APPROACH,

WHICH IS SOMETIMES KNOWN AS THE "NO PROBLEM" APPROACH, TAKES THE STAND THAT WE HAVE HAD PROBLEMS IN OTHER PROGRAMS, BUT WE HAVE ALREADY LEARNED ALL THE ANSWERS, SO WE WILL ENCOUNTER NO PROBLEMS ON THIS PROGRAM AND THEREFORE DON'T HAVE TO PLAN EXTRA TIME, OR BUDGET EXTRA MONEY, TO COVER CONTINGENCIES.

THE SECOND, AND MOST SERIOUS PROBLEM WE HAVE DISCOVERED, WAS THE FAILURE OF NASA TO UNDERSTAND HOW DIFFICULT IT WOULD BE TO INTEGRATE A VERY COMPLEX UPPER STAGE FILLED WITH LIQUID HYDROGEN AND OXYGEN INTO THE SHUTTLE PAYLOAD BAY. THE COMMITTEE VIEWS THIS FAILURE WITH CONSIDERABLE ALARM SINCE THE POTENTIAL PROBLEMS NASA MIGHT FACE IN THIS AREA WERE POINTED OUT REPEATEDLY BY THIS COMMITTEE IN THE PAST. WE FULLY SUPPORT THE SAFETY REQUIREMENTS IMPOSED UPON SHUTTLE PAYLOADS AND AGREE THAT THEY ARE NECESSARY TO PROTECT THE CREW. WE CANNOT UNDERSTAND WHY NASA AND AN INSTITUTION DID NOT COMPREHEND HOW DIFFICULT THE INTEGRATION WOULD BE AND PLAN ACCORDINGLY.

FINALLY, WE WILL LOOK AT SEVERAL ENGINEERING PROBLEMS WHICH DEVELOPED DURING THE COURSE OF PRODUCTION. THE MOST SERIOUS INVOLVED LEAKS IN THE FORWARD HYDROGEN TANK BULKHEAD WHICH REQUIRED REENGINEERING. THAT PROBLEM CONCERNS US FOR TWO REASONS. THE FIRST IS THAT IT REPRESENTS AN ENGINEERING FAILURE IN THAT THE FLIGHT VEHICLES WERE NOT BUILT TO DESIGN SPECIFICATIONS, AND THAT VARIANCE FROM CONTRACT SPECIFICATIONS CAUSED THE TANK FAILURES. AND SECONDLLY, WHILE THE GALILEO AND ULYSSES FLIGHT VEHICLES WILL BE REPAIRED, AND WE EXPECT THEM TO

PERFORM AS ADVERTISED, THERE IS STILL THE QUESTION OF WHAT CORRECTIONS WILL BE REQUIRED FOR FUTURE SHUTTLE CENTAURS IN BOTH THE G-PRIME AND G CONFIGURATIONS.

THE MOST IMPORTANT CONTRIBUTION THIS COMMITTEE CAN MAKE TO OUR NATIONAL SPACE PROGRAM THROUGH THESE HEARINGS WILL BE TO PROVIDE A FORUM IN WHICH WE CAN DISCUSS EACH OF THESE FAILURES AND UNDERSTAND HOW THEY CAME ABOUT. WE WILL BE ASKING THE WITNESSES HOW THESE PARTICULAR FAILURES CAN BE AVOIDED IN THE FUTURE. AT THE END OF THESE HEARINGS, I TRUST WE WILL BE ABLE TO SEE INSTITUTIONAL CHANGES WHICH WILL PROTECT US IN THE FUTURE. AS IT SAYS ON THE ENTRANCE OF OUR NATIONAL ARCHIVES, "THOSE WHO DO NOT LEARN FROM THE PAST ARE DOOMED TO REPEAT IT."

Mr. NELSON. So let us proceed, and Mr. Beggs, we welcome you.

STATEMENT OF HON. JAMES. M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JESSE MOORE, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT; ANDREW STOFAN, DIRECTOR, LEWIS RESEARCH CENTER; and LARRY ROSS, DIRECTOR OF SPACE FLIGHT SYSTEMS, LEWIS RESEARCH CENTER

Mr. BEGGS. Thank you, Mr. Chairman, and members of the committee, I welcome the opportunity. If I may make a couple of comments to your statement.

If the Congress decides on the freeze—and I understand the need for that in the current economic environment—NASA will structure its budget in such a way as to try to preserve those programs in which we have a large investment, and we will have to sacrifice, therefore, those programs which are relatively new, and in which we have either no or small investment. That is the way we will proceed.

The program we are discussing this afternoon is, of course, one where we do have a substantial investment. We are confronted by a substantial overrun and so, we are going to have to deal with that as well, within that constrained budget environment.

As you know, Mr. Chairman, nearly three years ago, we embarked on a challenging mission to transition the Centaur vehicle into a high-energy upper stage of the space transportation system. The primary objective was to provide two STS/Centaur upper stages for back-to-back planetary launches in the May–June 1986 timeframe.

Shortly after that, NASA also entered into an agreement with the DOD to develop and provide a shorter version of our planetary configuration as a common NASA/DOD vehicle. This common vehicle is planned to be operational in 1987.

We have proceeded to meet this challenge and, to date, we have completed the design phase for both the common and planetary vehicles on or near schedule. The planetary test vehicle has been built and is currently completing structural testing. As a matter of fact, we have now proceeded to the point where the initial structural tests are completed. Those were made at the contractor's Sycamore Canyon test facility.

The test vehicle program has experienced some problems and delays. The first was the late delivery of the Centaur support structure to the test area. The support structure is a multipurpose structure that holds the Centaur vehicle in the shuttle payload bay. The late delivery of the support structure was caused by a redesign due to increased structural loads requirements. Once the test vehicle was installed at Sycamore Canyon, two additional delays followed.

First, a fit check of the liquid hydrogen tank external insulation blankets proved to be troublesome, requiring a series of adjustments on the blanket assemblies. Following the fit checks on those blankets, and after a series of propellant loading and pressurization tests, cracks were found in the top part of the liquid hydrogen tank's forward dome.

A thorough investigation ensued to identify the source of the problem. The results of this investigation concluded that a beef-up in the top of the tank was required. The beef-up was added to the test tank and revalidation testing has been successfully completed. These tests included the original required test activity, plus some additional testing to satisfy us that a similar fix, when applied to the flight tanks, will result in sufficient margin for them to be acceptable for flight.

This phase of the Sycamore test program will be completed approximately 6 months later than planned. This delay has required the application of additional manpower to conserve as much schedule as possible, and the deletion of the structural pathfinder activity at Kennedy Space Center.

As for the flight hardware, the first STS/Centaur support structure and flight vehicle fabrication is in process. This is the hardware that we use for the Galileo mission. The Centaur support structure is build and is in final assembly at this time. The flight vehicle has had the liquid hydrogen tank beef-up modification completed, and is in preparation for returning to the final assembly area to continue the final assembly activity. We have encountered some difficulty in the fabrication of the support structure and vehicle tank assembly due to part shortages. We are also experiencing some difficulty in acquiring space-qualified electronic piece parts for avionics boxes and in timely deliveries of certain subcontractor components that go on the support structure and vehicle assemblies. The impacts of these shortages are increased manpower to maintain schedule and late availability of flight components for installation at General Dynamics' San Diego plant.

The first article's total factory acceptance test program will be performed at the launch site instead of at San Diego. We had initially planned to repeat the factory test profile at the launch site, so we believe this change in plans is acceptable. We are still planning to ship the flight support structure and vehicle to the launch site earlier than the ship dates established in 1982 and on or near the program's goal dates established in 1983.

The second set of flight hardware, to be used for the Ulysses mission, has been fabricated. The support structure is ready to start final assembly, and the vehicle is being prepared to go the manufacturing area for the beef-up modification to the liquid hydrogen tank dome. Here again, we are expending additional manpower to maintain schedule. We have also experienced many of the problems of the Galileo vehicle except to a lesser degree. The factory acceptance test for the Ulysses vehicle is still planned at San Diego, and delivery of the flight hardware is planned to be on or near the established goal date, which is in advance of the original delivery date.

With regard to the development status of the common NASA/DOD vehicle, we have completed the design phase and the structural test vehicle is in fabrication. The 6-month delay in the ongoing structural test program at Sycamore Canyon will impact the common structural test program by about 4 months. We plan to minimize the impact by, again, adding additional manpower. Moreover, since the liquid hydrogen forward dome problem surfaced prior to the start of fabrication of that assembly for the common

vehicle, a redesign of part of the liquid hydrogen tank can be done prior to proceeding. By applying additional manpower and paralleling some of the major common vehicle activities, we still plan to deliver the flight hardware on the schedule committed to in 1982.

As for the associate contractor hardware that is being provided by Pratt & Whitney, Teledyne and Honeywell, the production RL0 engines for both the Galileo and Ulysses missions are complete and have been delivered to General Dynamics. The vehicle computers built by Teledyne are on schedule; one computer has been delivered to General Dynamics, and the second is in production. The inertial measuring group hardware, made by Honeywell, is in production and unit fabrication is on schedule.

In the area of integration, the activities at the Kennedy Space Center to accept and process the STS/Centaur vehicles are moving along quite well and are on schedule. The modifications to the two shuttle orbiters are also proceeding well. Orbiter 104, the T3Atlantis,T1 were completed at Palmdale, and Orbiter 099 modifications are in work at KSC at this time. In addition to these modifications, the mission kits to be installed in the orbiters prior to the May 1986 missions are also being developed on schedule.

The payload analytical integration effort is now proceeding well. However, it is clear that we underestimated the Centaur integration into the shuttle, particularly with regard to assuring the Centaur could be safely carried in the orbiter if an abort were required. This has required engineering redesigns, additional analyses, and Centaur hardware changes. We recently completed a major safety review, which has given us confidence that we have a safe system. The Centaur-to-spacecraft integration is also proceeding well, with good working relationships among all parties.

This brings us to the financial aspects of the program. When we proceeded on the joint NASA/DOD development program in the fall of 1982, we established cost targets for the program. We established reserves within those estimates to meet the normal changes in program scope, cover potential growth in contractor estimates. This cost at completion estimate remained constant through the submission of the fiscal year 1986 budget, $378.9 million for DDT&E, $194 million for Galileo and Ulysses, and $182.8 million for the first two DOD vehicles.

In October 1984, the Lewis Research Center adjusted their funding requirements to reflect experienced and the projected manpower overruns based on an internal review. This increase was adjusted out of our available program reserves and resulted in no increase in the total program. At that time, Lewis instructed General Dynamics to reexamine their estimate to complete. The initial results of this revised estimate were presented to the Lewis project manager and his staff at the end of January.

These data were presented to me the first week of February by the Lewis Research Center director, Mr. Stofan. At that time, I initiated a joint NASA DOD Cost Review Team to review the contractor's estimate. The joint review team met in a series of meetings starting in February, and going through mid-March with contractor technical, financial, and program personnel to assess the extent of the problem and establish the schedule and funding impact. In mid-March, the team met in Washington to finalize these findings

into a joint position. In the interim, General Dynamics corporate management reviewed the GD San Diego data and recommended establishment of additional funding reserves in the basic development-production contract. General Dynamics also submitted its proposed staffing level for the post-delivery management, engineering and launch operations support activities. These staffing levels were significantly higher than estimated by the Lewis project office based on their long experience with the Atlas-Centaur and Titan-Centaur Programs. This new information was supplied to the review team and was factored into their final position.

In summary, the results showed that the development of both vehicle configurations and production of the first two NASA vehicles will require additional funding of $100 to $110 million. The development portion is $60 to $70 million, of which $20 million will be funded by the DOD. The $20 million for the DOD is the amount over NASA's 1986 budget estimates that will take them to an agreed-to cap of $150 million for their share of development costs. The increase in the NASA operations for Galileo and Ulysses is approximately $35 to $40 million. The DOD is still assessing their position on the additional funding required for their two vehicles, and I might add, parenthetically, Mr. Chairman, that is their problem.

In summary, as we look at the STS-Centaur Program progress over the past 3 years, we have moved forward to meet the challenge of launching two planetary missions back to back in the May June 1986 timeframe. Our schedule, as it has been from the very start, remains very tight, but we believe doable. We have experienced some technical and schedule problems which require more funding than we planned at the outset, but we are confident that we will successfully launch two planetary missions in May 1986.

We are proceeding with the development of the common NASA-DOD Centaur stage, and will take the necessary programmatic actions required to assure its successful development for both essential national security and NASA missions.

Mr. Chairman, that completes my prepared testimony. All of us here would be happy to respond to questions.

[The prepared statement of Mr. Beggs follows:]

Statement of

James M. Beggs
Administrator

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Committee:

Nearly three years ago, NASA embarked on a challenging mission to transition a Centaur vehicle into a high energy upper stage for the Space Transportation System. The primary objective was to provide two STS/Centaur upper stages for back-to-back planetary launches in the May/June 1986 timeframe. Shortly after that, NASA also entered into an agreement with the DOD to develop and provide a shorter version of our planetary configuration as a common NASA/DOD vehicle. This common vehicle is planned to be operational in 1987.

We have proceeded to meet this challenge and, to date, we have completed the design phase for both the common and planetary vehicles on or near schedule. The planetary test vehicle has been built and is currently completing structural testing at the contractor's Sycamore Canyon (CA) test facility. The test vehicle program has experienced some problems and delays. The first was the late delivery of the Centaur Support Structure to the test area. The support structure is a multipurpose structure that holds the Centaur vehicle in the Shuttle payload bay. The late delivery of the support structure was caused by a redesign due to increased structural loads requirements. Once the test vehicle was installed at Sycamore, two delays followed. First, a fit check of the liquid hydrogen tank external insulation blankets proved to be troublesome requiring a series of adjustments on the blanket assemblies. Following the fit checks on these blankets and after a series of propellant loading and pressurization tests, cracks were found in the top part of the

liquid hydrogen tank's forward dome. A thorough investigation ensued to identify the source of the problem. The results of this investigation concluded that a "beef-up" in the top of the tank was required. The "beef-up" was added to the test tank and revalidation testing has been successfully completed. These tests included the original required test activity plus some additional testing to satisfy us that a similar fix, when applied to the flight tanks, will result in sufficient margin for them to be acceptable for flight. This phase of the Sycamore test program will be completed approximately 6 months later than planned. This delay has required the application of additional manpower to recover as much schedule as possible and the deletion of the structural pathfinder activity at KSC.

As for the flight hardware, the first STS/Centaur support structure and flight vehicle fabrication is in progress. This is the hardware that will be used for the Galileo mission. The Centaur support structure is built and is in final assembly at this time. The flight vehicle has had the liquid hydrogen tank beef-up modification completed and is in preparation for returning to the final assembly area to continue the final assembly activity. We have encountered some difficulty in the fabrication of the support structure and vehicle tank assembly due to part shortages. We are also experiencing some difficulty in acquiring space-qualified electronic piece parts for avionics boxes and in timely deliveries of certain subcontractor components that go on the support structure and vehicle assemblies. The impacts of these shortages are increased manpower to maintain schedule and late availability of flight components for installation at General Dynamics' San Diego plant. The first article's total factory acceptance test program will be performed at the launch site instead of at San Diego. We had initially planned to repeat the factory test profile at the launch site, so we believe this change in plans is acceptable. We are still planning to ship the flight support structure and vehicle to the launch site earlier than the ship dates established in 1982 and on or near the program's "goal" dates established in 1983.

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As for the associate contractor hardware that is being provided by Pratt & Whitney, Teledyne and Honeywell, the production RL-10 engines for both the Galileo and Ulysses missions are completed and have been delivered to General Dynamics. The vehicle computers built by Teledyne are on schedule; one computer has been delivered to General Dynamics and the second is in production. The Inertial Measuring Group hardware, made by Honeywell, is in production and unit fabrication is on schedule.

In the area of integration, the activities at the Kennedy Space Center to accept and process the STS/Centaur vehicles are moving along quite well and are on schedule. The modifications to the two Shuttle Orbiters are also proceeding well. Orbiter 104 modifications were completed at Palmdale, and Orbiter 099 modifications are in work at KSC at this time. In addition to these modifications, the mission kits to be installed in the orbiters prior to the May 1986 missions are also being developed on schedule.

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This brings us to the financial aspects of the program. When we proceeded on the joint NASA/DOD development program in the fall of 1982, we established cost targets for the program. We established reserves within those estimates to meet the normal changes in program scope and cover potential growth in contractor estimates. This cost at completion estimate remained constant through the submission of the FY 1986 budget, $378.9 million for DDT&E, $194 million for Galileo and Ulysses, and $182.8 million for the first two DOD vehicles. In October 1984, the Lewis Research Center adjusted their funding requirements to reflect experienced and projected manpower overruns based on an internal review. This increase was adjusted out of our available program reserves and resulted in no increase in the total program. At that time, Lewis instructed General Dynamics to reexamine their estimate to complete. The initial results of this revised estimate were presented to the Lewis project manager and his

staff at the end of January. These data were presented to me the first week of February by the Lewis Research Center Director, Mr. Stofan. At that time, I initiated a Joint NASA/DOD Cost Review Team to review the contractor's estimate.

The Joint Review Team met in a series of meetings starting in February, and going through mid March with contractor technical, financial, and program personnel to assess the extent of the problem and establish the schedule and funding impact. In mid-March, the team met in Washington to finalize these findings into a joint position. In the interim, General Dynamics corporate management reviewed the General Dynamics/San Diego data and recommended establishment of additional funding reserves in the basic development/production contract. General Dynamics also submitted its proposed staffing levels for the post-delivery management and engineering and launch operations support activities. These staffing levels were significantly higher than estimated by the Lewis project office based on their long experience with the Atlas-Centaur and Titan-Centaur programs. This new information was supplied to the review team and was factored into their final position. In summary, the results showed that the development of both vehicle configurations and production of the first two NASA vehicles will require additional funding of $100-110 million. The development portion is $60-70 million, of which $20 million will be funded by the DOD. The $20 million for the DOD is the amount over NASA's 1986 budget estimates that will take them to an agreed-to cap of $150 million for their share of development costs. The increase in the NASA operations for Galileo and Ulysses is approximately $35-40 million. The DOD is still assessing their position on the additional funding required for their first two vehicles.

In summary, as we look at the STS/Centaur program progress over the past three years, we have moved forward to meet the challenge of launching two planetary missions back to back in the May/June 1986 timeframe. Our schedule, as it has been from the very start, remains very tight but doable. We have experienced some technical and schedule problems which require more funding than we planned at the outset, but we are confident that we will successfully launch two planetary missions in May 1986. We are proceeding with the development of the common NASA/DOD Centaur stage and will take the necessary programmatic actions required to assure its successful development for both essential national security and NASA missions.

Mr. Chairman, this completes my prepared statement. We would be happy to answer any questions. I would like to introduce Mr. Jesse Moore, Associate Administrator for Space Flight; Mr. Andrew Stofan, Director of our Lewis Research Center; and Mr. Lawrence Ross, Director of Space Flight Systems, at the Lewis Research Center.

Mr. NELSON. Thank you.

I want to make sure, now, that I understand correctly. You are talking about additional funding required in the range of 100 to 110 for NASA, or do you include DOD within that?

Mr. BEGGS. No, it includes the $20 million for the DOD. It is about 90 million max for NASA.

Mr. NELSON. All right, now, since you say that the Air Force will have reached its agreed-to cap of 150 million, then if Air Force requirements were to necessitate additional research and development funds, who will pay those costs? NASA or the——

Mr. BEGGS. Well, my position would be that if they levy additional requirements beyond that which we agreed to previously, Mr. Chairman, it would be on them.

Mr. NELSON. Ok, you say——

Mr. BEGGS. They haven't done that to date, to my knowledge.

Mr. NELSON. You said in your statement, "the increase in the NASA operations for Galileo and Ulysses is approximately $35 to $40 million."

Mr. BEGGS. For the vehicles that will launch those two spacecraft.

Mr. NELSON. I see. That is all within your $90 million figure.

Mr. BEGGS. Yes, sir.

Mr. NELSON. OK. All right.

If you missed the launch window next May, how long is it until another launch window?

Mr. BEGGS. Thirteen months, that is just by the nature of the position of Jupiter and our ability to launch. It is just the celestial mechanics of the thing.

Mr. NELSON. You said 13 months.

Mr. BEGGS. Thirteen months.

Mr. NELSON. What would be the cost associated with keeping the spacecraft and the launch vehicle and the personnel associated——

Mr. BEGGS. It would be a lot more than $90 million, Mr. Chairman. I haven't really got an answer to that. We will try to come up with an answer to that, but clearly, you know, you are going to have to keep the team together one more year. You would have to cope with the problems of keeping the spacecraft in storage, because it will be complete at that time. You would have to cope with the effect that would have on our ongoing shuttle launch manifest and a lot of other things, a lot of other minor and major impacts on costs. But, my offhand estimate is that it would be a lot more than the $90, or even $110 million that we are talking about here.

[Material refund to follows:]

To answer this question, we assumed the following groundrules:

1. Slip was not caused by an STS/Centaur technical problem.
2. Effort to launch proceeded on schedule through last possible moment.
3. Centaurs are returned to San Diego for storage.
4. Launch 13 months later does not conflict with any other STS/Centaur launches.
5. Vehicle Acceptance Test (VAT) will be redone.
6. KSC/JSC simulations will be redone.
7. Effort expended at ETR for May 1986 launch window will have to be duplicated for June, 1987 window.
8. NASA and DOD will share 50/50 on launch services for all four associate contractors from July 1986 through July 1987.

With these groundrules, the estimated additional cost to the STS/Centaur program is approximately $50 million, which includes about $10 million of contingency for unplanned changes and uncertainty of estimate. This is a NASA estimate since we do not have contractors' proposals for this scenario.

Mr. NELSON. How confident are you that you are going to make the 1986 launch window?

Mr. BEGGS. Well, I will ask my colleagues to respond as well, but right now, after a fairly extensive review of this thing, as I said in my statement, the schedule is doable. There are a few encouraging signs since this statement was prepared.

We have passed another milestone in the program, and it appears that we are, at least in the schedule we have laid for meeting those, that we are on that schedule, and indeed, holding it very well. So, [I] if you asked me today, I feel very confident, assuming, of course, we don't run into some other unforeseen difficulties, but we are—well, in my long experience with programs, you look for the—when you are in the development activity, you look for evidence of convergence, which is to say, are the problems getting smaller, or are they getting larger? In this case, I think the problems are getting smaller. I will ask any of my colleagues here to comment.

Mr. MOORE. Mr. Chairman, I will just add from the shuttle point of view——

Mr. NELSON. That is good news.

Mr. MOORE. We have made plans, as you are probably aware, of the shuttle flow down at the Kennedy Space Center next year, and have allocated a fair amount of time to flow a couple of orbiters and do some dry runs in terms of getting ready for these launches. So, we believe we have got from a flight point of view on the schedule program—the Shuttle Program—adequate time to handle the Centaur integrations and get them ready for flight.

Maybe Mr. Stofan will——

Mr. NELSON. Let me ask you a question on that, Mr. Moore.

When are the first units of Shuttle/Centaur hardware going to be shipped to KSC for processing?

Mr. MOORE. The Centaur integration support structure unit one is planned to be shipped to the Kennedy Space Center on June 27th, of June 1985; vehicle one is planned to be shipped to the Kennedy Space Center on August 15, 1985, and those two units support the Galileo vehicle; and then, unit No. 2, both the support structure and the vehicle is scheduled for delivery to the Kennedy Space Center on October 31, 1985, and November 21, 1985, respectively.

Mr. NELSON. November 21?

Mr. MOORE. November 21, respectively, yes, sir, for the flight vehicle No. 2 for Ulysses mission.

Mr. NELSON. All right, now, June, August, October, and November.

Mr. MOORE. Yes, sir.

Mr. NELSON. Has the contract with General Dynamics to cover the costs of processing at KSC, has it been signed?

Mr. MOORE. No, sir.

Mr. NELSON. Why not?

Mr. MOORE. Let me give you a status, and Mr. Stofan may want to elaborate on this, Mr. Chairman. We have received the proposal

from General Dynamics, and I believe we received it on the 8th of April. We are in the process of fact-finding at this point in time, and I expect to see a pre-negotiation position presented to me in the mid to latter part of June by Lewis Research Center, and we hope to then have a signed contract in the early part of July.

And I will ask Mr. Stofan if he would like to elaborate a little bit on that?

Mr. STOFAN. Yes, the contract to carry on the activities at the Cape, there is an existing contract going on, so we are covered totally to do the job we have to do. When that contract ends, we will sign the new contract, which will carry on the work into the future. So, it isn't that we are not covered. We are totally covered contractually to do all the work that is necessary at the Cape, and we are evaluating this proposal very carefully, because this is one of the areas that came in proposed by the contractor much higher than we had anticipated that it was going to be, and the explanation is due to the difficulty of integrating payload in the shuttle. They feel this is more complex, and it is outside our experience base. And we are in the process of evaluating this very carefully right now.

Mr. NELSON. When do you think this contract is going to be signed?

Mr. STOFAN. July 1.

Mr. NELSON. July 1. So you have got part of your hardware coming June 27, and you say that that is covered, even though you are not going to have a signed contract until July 1.

Mr. STOFAN. Covered under an existing contract. The one contract expires July 1, and the new one will pick up and follow on. So we have a contract that has covered them totally for anything that goes on at the Cape. And we will have this one signed, so there is no gap between them and no discontinuity.

Mr. NELSON. Ok, so, in no case would this new contract take effect before July 1 anyway? Had you had your druthers, and this thing had been speeded up, it still wouldn't take effect until July 1?

Mr. STOFAN. That is correct, because we have an existing contract to cover all the activities going on.

Mr. NELSON. Ok. All right, let's talk about some other contracts. Mr. Beggs, when was the initial contract signed with General Dynamics?

Mr. BEGGS. Oh, dear Lord, this goes on and on and on. You will recall, Mr. Chairman, that this program started and stopped a couple of times. There was a basic letter contract which was, as you know, a legally binding document issued in May of 1981. Then for all of the reasons that are well written in the record, it was phased out in March of 1982. Then it was restarted, again with a letter contract, in July of 1982, and at that time, the Air Force joined us and laid down their requirements for the short version, what we designated G-Prime—excuse me. The short version is G, the long version is G-Prime. And the contract was complemented then with those additional requirements in early 1983. So it—from July 1982 to 1983, we were adding to the letter contract. We then proceeded to negotiate a definitive agreement on that, and that was signed on October 31, the eve of all hallows.

Mr. NELSON. What year?

Mr. BEGGS. 1983.

Mr. NELSON. 1983.

Mr. BEGGS. And then, the G-prime and two DOD vehicles, that is, the hardware that we will fly with, was signed the following April 1984, April 13, 1984. So, it took a long time to get it negotiated and definitized.

Mr. NELSON. So, your final contracts on G and G-Prime were signed October 1983 and April 1984.

Mr. BEGGS. That is correct.

Mr. NELSON. Is that correct?

And the first letter contract on this thing started in May of 1981.

Mr. BEGGS. That is correct. That is correct. But there was, as you recall, Mr. Chairman, there was a hiatus——

Mr. NELSON. Of 1 year.

Mr. BEGGS [continuing]. Put in the program from——

Mr. NELSON. From May 1982 to July 1982.

Mr. BEGGS. To July—that is correct.

Mr. NELSON. So there was a hiatus of what, 2 or 3 months?

Mr. BEGGS. Well, it was really longer than that, it was in limbo. But that is essentially correct, yes, sir.

Mr. NELSON. Ok, now, what—if you had your druthers, as an Administrator, you wouldn't contract this way, I assume.

Mr. BEGGS. I would never, if I had my druthers, I would never issue a letter contract, that is right. A letter of contract immediately takes pressure off both sides to complete negotiations of a definitive contract. It takes the pressure off the contractor, he is covered, and he knows that as he accumulates costs, he can bring those costs in and put on the table as actuals and negotiate from that point. It takes the pressure off of the Agency, because we know the work is going forward, even though we don't have a definitive contract. And we say, well, we are meeting our schedules, therefore we can take the necessary time in order to ensure that this negotiation is exactly right.

In my long experience in this industry, I have been party to, and I am not proud of it, but I have been party to letter contracts which go on to the point where the hardware is delivered. Then everything is actual. And that is very bad. Because it takes all of the risk out of the job, and there is no incentive left for either party to have done anything differently in order to either minimize costs or ensure delivery.

So it took us a long time to do this, and I am not terribly proud of that, but there were a lot of reasons why that went on. First of all was the question of getting the DOD requirements nailed down. We wanted to put those in a single contract. Second, was this stop-start procedure, and the problem that we had with the contractor and his subcontractor structure, some of which in the interim had gone out of business. He had to go back and redo his estimates and redo everything that he submitted as validation for the estimate he had given us, the prior estimate he had given us. And, I guess there were a lot of other reasons that crept into the thing. But given all of that, and with everything that one looks back on, you wonder why it took that long.

Mr. NELSON. Well, I appreciate you sharing with us the reasons of why it took all of that period of time for the contracting to be finalized. Could I be so bold as to ask, since you have stated the disadvantages of letter contracts, why a letter contract was signed by NASA in May of 1981?

Mr. BEGGS. Because we were up against the flight schedule. As we discussed earlier, we were on the hook to get that Galileo vehicle off. If we missed that window, we were stuck for 13 more months, and that had a major cost impact on the agency. So, we felt that it behooved us to get the program started in order to meet that date since we were shifting the Galileo vehicle from the IUS, where it was at that time proposed to fly, to the Centaur. That required several things.

It required that the Galileo team get immediately on with the job of integrating with the Centaur. It also meant that once you had given JPL the authorization to go forward with integrating on Centaur, that you had to ensure that you had a Centaur vehicle available there, because they couldn't at that point integrate back onto the IUS. So, we were stuck with schedules, and I might add, that generally is the case on most of the letter contracts that you get into in this business, is that you are stuck with a very tight time schedule, and we were on the horns of that, and we had, as you know, Mr. Chairman, we had already gone through this cycle once. So, having at this point the second iteration, we decided we had to get going.

Mr. NELSON. Now, at that point, in May 1981, when you felt that you had to meet that window, was that still the May 1986 launch window, or it was an earlier window, was it not?

Mr. BEGGS. It was an earlier window.

Mr. NELSON. 1985, wasn't it?

Mr. BEGGS. 1985.

Mr. NELSON. A 1985 window.

Mr. BEGGS. We had decided prior to issuing that letter contract that we had missed the 1985 window. We wanted to make the 1986 window, we had to make sure that we didn't lose any moretime. This was discussed in great detail.

The date that we missed the 1985 window was—I will get you that for the record, Mr. Chairman, but we went through this a couple of times. There were several iterations of this.

[The information follows:]

In May 1981, the Agency was planning to launch both Galileo/Ulysses (ISPM) in the April, 1985 launch opportunity. In December 1981, the contract was terminated and all program activities were stopped. In July 1982, the program was reinitiated, and at that time, it was determined that launch of Galileo and Ulysses in 1985 was not feasible and we began planning for dual launches in 1986.

Mr. NELSON. All right, so you were looking in May 1981, you were not expecting to hit the 1985 launch window, when you signed the letter contract, you were expecting to hit what we are still trying to hit, which is the launch window in May 1986, is that correct?

Mr. BEGGS. I believe that is correct, yes, sir.

Mr. NELSON. OK.

Now, looking back on it and knowing what we all know now, given the same time constraints and so forth, would you sign another letter contract?

Mr. BEGGS. Yes, I would sign another letter contract. In retrospect, we probably would put more pressure on to have definitized that contract. Although I can't say that the definitization process really had any real impact on the problems that we are facing today. It might have made clear the problems that we have, at least to some extent, it would have made clear the problems we had in budget a little earlier.

Mr. NELSON. Would it have saved you any money?

Mr. BEGGS. I doubt it. Basically, Mr. Chairman, we are on a cost reimbursable basis on this thing. There is only one incentive in this contract, and that has to do with the success of the launch, so the likelihood of saving any money on this thing—the only thing we could have done there is put some incentives on costs, but the problem with that is that we were pressing for schedule, and it is difficult to configure a cost incentive-type contract when you are pushing them hard for schedule.

Mr. NELSON. So between May 1981 and April 1984, when your final definitive contract was signed, the speeding up of that 3-year period would not have saved you any appreciable cost?

Mr. BEGGS. I don't believe it would have saved us a great deal. I think one can second-guess, you know, with 200 hindsight on this, we could have gone back perhaps and looked hard at the question of some additional incentives that we might have put into the contract.

But I don't think it would have changed appreciably over the cost. The plain facts are, we underestimated the job of integrating the Centaur into the Shuttle. General Dynamics on their part, underestimated the cost of changing the configuration. They assumed that they would be able to take a standard Centaur that rode on the top of an Atlas or a Titan and simply applying the same manufacturing techniques and the same design techniques, build a larger-diameter, shorter-length Centaur.

That turned out to be a fallacious assumption. Both the problem I mentioned in my prepared statement of the cracks that developed in the dome, as well as the welding problem in general on that vehicle, and the structural design of the vehicle proved to be a much higher, larger challenge than just simply taking existing technology and converting it to a larger-diameter vehicle.

I know we have heard that before, but there were some reasons for us to believe that we could do that. We had gone over that very carefully, and the folks who were in the design of this thing, I should add, had been designed and built and flown very successfully for 15 years, I guess, or 20, gave us a lot of confidence. We said, we have got a vehicle here that has got a lot of experience, we have a lot of experience in manufacturing it, we really think that the problems that we have got in converting it are straightforward and will yield to standard engineering practices, and we were wrong.

Mr. NELSON. We will get General Dynamics testimony come Thursday, and before I turn to Mr. Packard, let me ask you this question about General Dynamics:

It is my understanding that they are—their engineering team is really being challenged to keep on this schedule. And I am curious, is their engineering effort—that now a requirement to give the Air Force an upgraded Titan, is it having any negative impact on the Shuttle/Centaur, in your opinion?

Mr. BEGGS. My opinion, no. But it is something that we are going to have to watch very carefully. Because, obviously, the Titan Centaur, the Titan D 7, or whatever they are going to call it, 34 D 7, is also on a tight schedule. And, if they were to start slipping on that schedule, if they were to start falling behind on supplying that hardware, obviously, it would put great pressure on them to take manpower from wherever they found it, because that is a high-priority DOD Program. So, we are going to have to watch that very carefully, and if we see something like that happening, we are going to have to step in and do one of several things, or maybe several of several things, one is to demand that they hold to their commitment to us, that is, to keep the manpower on that they had, or to back them up with manpower from NASA, which we have done in the past, or to go out and seek help wherever we could find it to back them up. And we will do that.

Mr. NELSON. To commercialize Atlas Centaur, is that detracting at all from Shuttle/Centaur?

Mr. BEGGS. I am sorry that I chuckled. First, you would have to sell some, and I really don't see where the market is for an Atlas Centaur.

Mr. NELSON. All right, Mr. Packard?

Mr. PACKARD. Mr. Chairman, we have a vote, and I really appreciate the opportunity to sit with this subcommittee, even though I am not a member of this subcommittee, I am on the full committee, I have several questions that I hope will not take long, but let me suggest that we do it maybe when we reconvene.

Mr. NELSON. Ok. If Mr. Torricelli gets back before I do from the vote, we will have him resume the hearing. That is why we sent him ahead of time, so we can proceed.

The committee will stand in recess.

[Recess.]

Mr. TORRICELLI [presiding]. If the committee can come back to order? Thank you for your patience, and while Mr. Nelson is at the Rules Committee, I would like to proceed.

At this time, I would like to recognize Mr. Packard, please, for questions he might have.

Mr. PACKARD. Thank you, Mr. Chairman, I want to express my appreciation for being invited and privileged to come and participate in this hearing, even though I am not a member of the subcommittee, I certainly am interested, and particularly as it involves in my area some of those who are assembling and building the facilities at General Dynamics in San Diego.

Mr. Beggs, in your testimony, you indicated that you are experiencing some difficulty in acquiring space-qualified electronic pieces and parts for avionics boxes and other items that subcontractors are assembling, and also that very well could be causing some of the delays at General Dynamics, in terms of their work.

Where and why are we experiencing these specific delays?

Mr. BEGGS. Mr. Packard, this design which has been alluded to before, is over 20 years old. As a matter of fact, from the time that the design for the Centaur was initiated, it is probably like almost 25 years. That is, from the concept. And the electronics, while they have been updated slightly over the 20 years the vehicle has been in production, are very old electronics. They are pieces and parts which are well-proven, and have proven to be very reliable over the years, but they are not things that you can get readily on the marketplace. And of course, we don't buy them in any quantity, we buy—as you know, we are producing maybe half a dozen of these vehicles over the next several years. So, to get our suppliers to build those pieces and parts is something that requires some time. They don't put it high on their priority list, and it has been difficult for us to get them to deliver those pieces and parts on time.

I might add, that is not a unique problem in this business. NASA has a problem across the board in buying the relatively small quantities of electronics which we buy. We want high-reliability parts, we want parts which are well proven which we have bought before, in most cases, and sometimes they are out of production, sometimes the supplier just simply does not produce that part as a commercial item, so it is not something he wants to set up and do for you at the drop of a hat.

Mr. PACKARD. Have change orders had something to do with the delays also?

Mr. BEGGS. Well, we haven't changed the electronics yet significantly, although we have looked at the possibility of going to more modern avionics in this system with the Air Force. The Air Force does have generally a feeling that one ought to update avionics periodically.

My view on that is that if we have got something here that has proven highly reliable in the past, we ought to stick with it, but we have looked at that in terms of updating it and changing it. But to date, we haven't changed it, except in those cases where we absolutely can't buy the part, we have had a few of those, where you can't buy the part you have got to, obviously, you have got to engineer around it, and we have done that in several cases, not a large number.

Mr. PACKARD. The window that has been adhered to in terms of launch time, which is a fixed time, if in the event either simply we cannot provide the equipment in time or the equipment is—obviously, we are not going to send the equipment that is not well—contructed and tested, if it is not met, if we do not launch on the May date in 1986, then—is it May, I think it is May——

Mr. BEGGS. Yes, sir, that is correct.

Mr. PACKARD [continuing]. Then, how much—what kind of costs would that incur? You indicated it would be quite substantial?

Mr. BEGGS. It would be very substantial if we had to incur a 13-month delay, which is what would be required. That is simply dictated by the celestial mechanics of getting to Jupiter in the case of Galileo, and that requires a 13-month delay. I might add, Mr. Packard, we didn't go into this, and the record might benefit by some exposition on this. We went through several iterations as to how we were going to do this mission.

When I arrived on the scene, the program was configured so in two launches, we were going to use the IUS, we were going to launch the Galileo orbiter, that is, the spacecraft that will enter the orbiter around the giant planet on one mission. And then we were going to launch the Galileo probe, the vehicle that will enter the Jovian atmosphere and penetrate down to 2,000 atmospheres or so on another mission.

That was simply due to the lift capabilities of the IUS. That, of course, is why the Centaur integrated in the shuttle became attractive in the first place. And the Congress looked into that in—well, as early as 1980, but they did authorize us, and directed us to proceed with it in 1981, and then several events transpired and we backed away from that and went back to IUS, put a hiatus into the program, and then, as has been cited before, we decided in the next session of the Congress to go back to the Centaur with a launch of the whole spacecraft and probe.

As a consequence of those several events, the launch slipped from—my colleagues will correct me here—1981 or 1982 to 1983—1982 to 1983 to 1984 to 1985, and now to 1986, so it has slipped several times due to the fact that we had these changes in the program, and I should add, also due to the fact that the spacecraft itself went late in the early years.

So, we have already experienced several slips, which have been expensive, in the program. It would be very bad, in my judgment, to have it slip one more time, for another 13 months.

Mr. PACKARD. A little over a year ago, it was determined that the cost overruns would be somewhere around 50 or $60 million, and now we are saying $100 or $110 million. Is that because of the slippage, and will we be expecting cost overruns to increase even above the $100 million that we are now projecting?

Mr. BEGGS. I think the cost overruns that we are projecting currently are due more to the technical problems we have run into, rather than to schedule pressures, although schedule pressures certainly play their part, but the problems that we mentioned on the cracks in the dome, which is a structural problem, was unforeseen early on, the problems that we would run into in learning how to weld this larger diameter structure, the various and sundry engineering problems that were connected with the integration of the vehicle with the support structure into the Shuttle, all of those are technical problems.

And I would have to conclude from a very close review of the thing that it is our technical problems that resulted in the major part of the overrun rather than the schedule problem. However, because of the slippage that we have incurred as a result of the technical problems, we are going to have to add manpower, and adding manpower costs money, so from here on out, we will be absorbing increased manpower costs.

In a more direct answer to your question, if those manpower costs get significantly higher than we are currently estimating, then our current estimate would be off to some degree. But as I have said in response to another question, in my long experience with program management, the chief thing you look for, are the problems converging or diverging, that is, are the problems getting smaller or larger? In this case, they appear to be getting smaller.

Now, we still have some hurdles to get over, but currently, we are meeting milestones and the problems we are dealing with appear to be problems that we can handle.

Mr. PACKARD. Would the chairman permit me one additional question?

Mr. NELSON [presiding]. Certainly.

Mr. PACKARD. The system appears to be fairly close to qualifying for launching, and it appears that we will meet the deadlines. How many launches of the Centaur Shuttle System do we anticipate if we meet the next window? In the next 5 to 10 years, what is anticipated in terms of flights, using this system?

Mr. BEGGS. Well, I would say anywhere from 5 to 10. We know of seven.

Mr. PACKARD. You know of seven.

Mr. BEGGS. That we have currently on the books. The DOD, assuming that their vehicle meets their requirements, I would say, will come along with another three or four, and we probably, as we bring more planetary missions into our program, these are things out in the nineties, we will no doubt use the Centaur for additional launches. So, in the next 5 to 10 years, my guess is this is going to be a real workhorse, just as it has been a work horse in the last 20 years.

Mr. PACKARD. Thank you very much.

Mr. Chairman, I had the privilege of being briefed, and reviewing the construction of the Centaur in San Diego at General Dynamics a couple of months ago, and I sincerely appreciate the opportunity to come and participate in this hearing because of my personal interest. Thank you very much.

Mr. NELSON. Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

Welcome, gentlemen, I appreciate your coming before us today. Have you given any consideration to adopting some institutional mechanism that would bring the manned spacecraft people at the Johnson Space Center into the loop earlier to reduce the potential for integration problems in the future?

Mr. BEGGS. We have given a lot of thought, and have discussed at great length this question of integration into the Shuttle from several points of view.

One is the question of, are we imposing too severe a set of requirements to get on the shuttle? And this is true across the board, whether we are dealing with ourselves, as in this across the board, or with our commercial customers, or with the DOD, all of whom are very much interested in reducing the time it takes to get on board the shuttle. I have got to say that in this case, the Johnson people were involved right from the beginning. They were a part of the integration team from the beginning. We had, however, two different centers involved.

Lewis was doing the development program, and Johnson had responsibility for the integration, and I guess I would be less than candid if I didn't say that such a relationship always has some startup problems. And Lewis and Johnson hadn't really worked on a problem like this in quite some time. My friend here to my left may object in degree to that, but I don't think he will object to the general statement that there are always problems in getting the re-

lationships established at the working level. However, I do think that the Johnson people were pretty well plugged in to what we were involved in, and I think were committed to the idea that they wanted to get the Centaur integrated into the shuttle as quickly and effectively as possible.

Having said that, I guess we also should say that the task has proven a little more difficult than we estimated, and technically, it proved to be a more detailed and sophisticated an engineering challenge as we had estimated.

I don't know whether changing the procedures by which we make that interface would help or not, other than, as I said in the beginning, trying to simplify and make as simple as possible the requirements that you lay on anyone who wants to get integrated into the shuttle.

Jess.

Mr. MOORE. I think, Mr. Walker, another point should be made, is that the JSC people were involved early on in this process. We have now completed modifications to the *Atlantis* vehicle for putting the Centaur in the shuttle, and we know what mod kits we have to put into the *Challenger* vehicle. Those are the two orbiters we plan to modify. We are also in the process, and have designed the mission kits to adapt the Centaur for the Ulysses and Galileo missions, so we have done that kind of design.

I think Mr. Beggs' comment about analytical integration is probably one that we may not have paid attention to from the outset, but the other factor is that the reason why some of these structures changed, was we got a new loads analysis after flying the orbiter for a few flights, we understood a little bit more about the loads on the orbiter. And that also forced some changes into the integrated support structure. And, I think that just the fact that the shuttle/Centaur fills up the entire cargo bay, it is a highly capable upper stage system, it is also a very complex upper stage system.

And I think the other thing I would like to say is we just completed our phase II safety review. As you know, we have three phases of safety reviews on the shuttle with respect to Centaur, and we have seen no show-stoppers in there from a safety standpoint. That was a very comprehensive review that was conducted a month and a half ago by the most senior people we have got at Houston.

So I think in summary, yes, there are some things we probably could have focused on a little bit earlier, but I think also that JSC did quite an adequate job of ensuring we had the hardware manifest and the orbiters manifest in order to accept this hardware when it gets ready for flight.

Mr. NELSON. We are going to recess.

Mr. WALKER. Can we pursue this? I have several more questions to pursue when we get back.

Mr. NELSON. Certainly.

[Recess.]

Mr. WALKER [presiding]. Jess, let me come back at you on a couple of things that you were saying there just before we broke.

Hasn't it been pretty difficult to work out the safety limits for a potential with regard to the launches? Haven't we had some problems and difficulties there?

Mr. MOORE. Well, I am not sure exactly what you are referring to, Mr. Walker. The one thing we are working on right now as far as the Centaur, shuttle/Centaur launch is concerned, is a probability of a catastrophic event relative to the RTG's on board, and that is issue is looking at the safety aspects of this, if that is what you are referring to. But we have done an analysis of that, and have determined that the launch of the shuttle/Centaur system with the two planetary spacecrafts on board gives us an acceptable, we believe is quite an acceptable probability of a safe launch, relative to launching these two cargoes. And we have done a fair amount of analysis on that, and are working with the Department of Energy and others in terms of looking at that situation, Mr. Walker.

Mr. WALKER. Mr. Stofan, do you feel that you and your team fully understood the problems of putting the Centaur into the shuttle?

Mr. STOFAN. I am sure we did not fully understand the difficulty of putting the Centaur into the shuttle. It turned out to be our experience, it had been, say, some 20 years with unmanned launch vehicles and building and launching them, and when we started to integrate the Centaur into the shuttle, when we estimated the cost, both General Dynamics and ourself, of what the difficulty would be, it was based upon our past experiences. And as it turned out, it was far more complex and therefore, more costly than we had anticipated, and we underestimated the difficulty of the job.

Mr. WALKER. Can I assume then, in hindsight, you would have done some things differently?

Mr. STOFAN. I would have estimated the job differently. Not technically, no, we would have done exactly the same thing; technically, we went into the safety world and there, safety does dictate, and we did what was necessary to make the stage safe. So, technically, we would have done the same things. We would have estimated a higher cost, though, to accomplish the safety. And it was safety reviews and analyses and things were much deeper and much more complex than we had anticipated.

Mr. WALKER. So in terms of the learning curve here, you are saying that you feel as though everything that was done was done right, that if we have a similar kind of situation in the future, that there is nothing in terms of process that you would change?

Mr. STOFAN. Well, we went through a learning process in dealing with a very complex spacecraft.

Mr. WALKER. Well, I understand that, and having gotten into it, you didn't understand the problems that you were dealing with up front, and you have gone through a process of doing some learning.

Now, I guess what I am asking is, having done that whole learning process, assuming that we have developed a learning curve out of that, are we saying, though, that everything that was done in that learning process was right, and so therefore, the learning curve is such that the next time we just do everything the same as you did it on Centaur?

Mr. STOFAN. Well, not everything right. We went through a learning process. It was a little bit more complex and difficult than

we had anticipated in the beginning. And had we realized that earlier, we would have estimated and probably attacked some of the problems and put more manpower earlier on given things that were complex that we didn't realize that they were.

Mr. WALKER. Well, I guess my question is, what have we learned? What is it that we need to do differently in the future given a similar kind of situation where we are trying to integrate one complex system with another complex system?

You know, it seems to me that we have had a valuable, if costly, experience here. We don't want to repeat another costly experience of a similar kind as we move into more complex kinds of integrations in the future.

This is certainly not going to be the most complex integration that we face. We are likely to come up with ones that are just as complex or perhaps even more complex in the future as we move into space stations and others.

And what I am trying to find out is for the costs that we have—incurred, what have we learned?

Mr. STOFAN. I think two things that come to mind right away. One is the entire structural analysis, the loads that are transmitted from the shuttle into the Centaur. This required extensive redesigns for us to go back after designs were released, and it turned out the loads were much, much higher, and to go into earlier load cycles, we have learned the importance of doing that.

I think the other one is that initially, we were looked at kind of as a payload in the shuttle rather than an integral part of the shuttle system, and it turns out the complexity, Centaur is the most complex that has been integrated into the shuttle to date.

And had we originally been looked at more as a cargo element, rather than a payload, that would have been the proper thing to do, and my recommendation would be, if we are going to do something that we anticipate to be that complex, to set it up and treat it a different way to start with.

And then again, to get the load cycles early. This really costs us time and effort, and we did not do it early enough. So those two things, I think, are two of the key things we have learned.

Mr. WALKER. I see that Mr. Moore is agreeing with you. And so, I assume that that reflects a fairly general viewpoint.

Let me follow that up with one additional question. What can we, as the authorizing committee, do that would be more helpful to you in assuring that these learning experiences are, in fact, implemented more efficiently in the future?

Mr. BEGGS. All right; I will get my head bloodied on this one. Without any question, the stop-start nature of this thing influenced the way we did it. Had we started this thing and decided we were going to do it this way in 1981, or even in 1980, we could have done a much better job in terms of both the handling of the time pressures that are and were on us, and in laying out a more rational program. Having said that, I understand the reasons why we got into this start-stop proposition, and they were not all controllable. But that would—in my judgment, it would have made a significant difference in the way we did this.

There were other mistakes in schedules made early on on this program. It has not been the world's best-run program in terms of

schedules and agreeing to the way in which we would perform the mission right from the beginning, and that always costs. When you start a mission of this complexity and then change several times during the course of development, it gets very expensive. And this one got very expensive.

Mr. WALKER. Is that in part because we weren't asking the right questions, or weren't asking the questions often enough?

Mr. BEGGS. No; I think you were asking the right questions. I think, in some respects, NASA was trying to answer those questions in consonance with the total program impact that we were seeing.

We saw an impact on the shuttle on this program a couple of times. As I said earlier, I don't know whether you were in the room or not, Mr. Walker, but at one point in time, this mission was configured for two launches on the shuttle, and then as we looked more closely at it, it appeared that we could do it a whole lot better, and indeed we are going to do it a whole lot better, we are getting a much more effective mission, but it has cost us a whole lot more money because we didn't anticipate some of the problems, and it has taken us more time, which maybe translates into the same thing.

Mr. WALKER. I simply have the perception, and I will yield back, that perhaps we failed, though, to understand completely the nature of the difficulties that you were facing and the extent of the difficulties that you were facing.

I am not certain that our hearing record is replete with instances where we fully comprehended the nature of the expense that was building, and the reason for that expense, and that we are kind of coming in here almost after the fact now and saying, you know, what went wrong?

When in fact, we ought to have been a part of maybe helping to solve those problems up front. Now, I don't know whether that is in part this committee failing to do its job right, or whether it is the fact that we didn't interpret the information from you correctly.

I mean, I don't know where the fault lies on that. But I do have a perception at least, that we have come to an awareness of the extent of the problem fairly late in the cycle.

Thank you, Mr. Chairman.

Mr. NELSON [presiding]. Mr. Monson.

Mr. MONSON. Thank you, Mr. Chairman.

Are we obligated under the contract to pay for all of these overruns?

Mr. BEGGS. Yes, sir; we are.

Mr. MONSON. And how do you anticipate doing that?

Mr. BEGGS. Well, I responded partially to that question earlier, that if the Congress approves a budget at the President's submittal, we think we can handle it within the budgetary reserves we have in NASA.

If we are frozen at the 1985 level, we are going to have to go back and cut something else out in order to preserve this.

Mr. MONSON. You would not have to cut into any other program, then, if you were funded at the level requested by the administration for 1986?

Mr. BEGGS. We are confident that we can handle it within our reserves. We would have to move some money around, obviously, but we would not impact—we do not believe we would have to impact programming.

But if we are frozen at the 1985 level, it will be a horse of an entirely different color.

Mr. MONSON. And have you looked at that horse yet? Do you know what most——

Mr. BEGGS. I have looked, in a preliminary fashion, at that horse. And it is going to be a much skinnier horse.

Mr. MONSON. But you don't know what programs yet you might——

Mr. BEGGS. No, but you know, what I have stated repeatedly when I am asked this question, is what I will do if the Congress allows me to do it, and I presume you will, if you decide to hold me at the 1985 level, or if you give me some discretion, I will preserve those programs in which the United States has a heavy investment.

And I will curtail severely those programs which do not have a large investment, in which I can postpone or even eliminate for the future, and there are—if you want me to cite some of them, some of them I can, but I really haven't—to cite them would, I think, be premature, because we really haven't made that decision. And I am prepared to make those kinds of decisions. This is a program that can be run, literally, at almost any level. If you tell me that I have $7.5 billion a year to run it, I can run it at $7.5 billion. If it is $7.5 billion, however, in 1985 dollars, we have to—90 percent of our money goes into the outside world. We buy hardware, we buy services, we put our money with the private sector, and we put it with the universities. That is where our money goes. And then you give us something over $1 billion to pay our people, which we have a little over 20,000. I might add parenthetically, that is down from 30,000 just about 12 years ago. So we have cut the personnel down to what I consider to be—this is not to say you couldn't take a few more out, but it is at what we consider to be a minimum number to run a rational program.

But you can tailor that program to any number that Congress and the administration decides to tailor. But you have got to tell me in advance how much money I am going to have in constant terms, over the years, because we don't run any programs in this agency that are not long-term. They all take 5 to 10 years to accomplish.

And when we buy stuff on the outside where we pay the normal installation, when we buy hardware, we pay whatever the labor escalation is and we pay whatever the material escalation is in the outside world. The same is true with the university communities. They up their costs, year by year, and in keeping with the economy. Otherwise, they couldn't attract good people. And that is only fair. So if you tell me I have got a fixed number of dollars, and that you are going to escalate, that is one program. If you tell me I have got a fixed number of dollars and it is not going to escalate, that is quite a different program.

Mr. MONSON. Without defining the exact areas that you might look to for this, as a new member, I would appreciate hearing what

some of these areas are that you referred to in your statement a minute ago that may be easier to drop because you could delay them, or for whatever reason?

Mr. BEGGS. We can give you a list of candidates, yes, sir.

Mr. MONSON. I would appreciate that.

Thank you, Mr. Chairman.

[The information follows:]

Question. If NASA is held to the FY 1985 funding level, which areas/programs will be delayed or dropped?

Answer. NASA's FY 1986 budget request is nearly level with the FY 1985 after providing for inflation.

A freeze at the FY 1985 level would reduce the NASA request by about $400 million from the FY 1986 request. A reduction in funding of this magnitude after the absorption of the additional requirements would require a major restructuring of the entire NASA budget. The newest projects with the least investments, such as the OMV, ACTS, ATP, and Commercial Use of Space would probably be delayed or deferred. Finally, a reduction of this magnitude would have a ripple effect throughout the NASA organization through the breakup of research teams, changes in detailed project schedules and deferral of testing and integration activities which, when combined with the effects listed above, make it a certainty that a budget freeze at the FY 1985 level would have a major adverse impact on NASA.

Mr. NELSON. Mr. Smith.

Mr. SMITH. No questions.

Mr. NELSON. What you just said, Mr. Beggs, was that if we ask you, you could tell us some of those programs that you would consider cutting. Why don't you share that with us?

Mr. BEGGS. Well, you know, there was new start in this program, that is the orbiting maneuvering vehicle, we would have to delay that, obviously. That would come off the top. I would look at programs like the advanced Communication Technology Satellite Program, which we are still not under definitive contract on, that would be another. We would look at programs like the second sourcing and competitive programs in areas like the shuttle main engine and the solid rocket boosters.

Mr. NELSON. You are saying that that would cause you to do that?

Mr. BEGGS. Yes, sir, I would have to assess those programs in which we have money set aside for competitive programs. I would have to look at those with a hard, cold eye and decide whether we can afford to do those in the near term.

Those programs will pay off in the long term, as you know, Mr. Chairman, but the cost is in the short term.

Mr. NELSON. I see what you are saying.

Mr. BEGGS. And I guess I would as well, look at things like the SOT Program, the sun observatory in the shuttle, which is just beginning in the science program, and there are some other things in the Science Program that probably could be curtailed somewhat.

Mr. NELSON. Gravity probe B?

Mr. BEGGS. That would be another, although we are not spending a great deal of money on that, but that would be another thing. It depends on, you are going to have to give us two signals, Mr. Chairman, you are going to have to tell us, "Here is the money. Here is what you are going to live with for fiscal year 1986."

But you are also going to have to give us some signal as to what we can expect in the subsequent years. If we can anticipate in fiscal year 1987 and 1988 getting back on a more normal escalator,

then that would influence my decisions in a different way. So you are going to have to give us that signal, too. If we are going to have to live with a fixed budget in these terms for some period of time, it means we are going to have to severely curtail what we can anticipate doing, because we are going to have to absorb whatever escalation that we will get in the ongoing program.

Mr. NELSON. I think that is a most reasonable request on your part, and it is only constrained by virtue of the fact that the appropriating process and the budgeting process goes on annually.

But there is a 3-year projection on this budget, and as soon as we know what has happened on Thursday night, in front of the house, we will know the general range of function—we won't know the general range—we will know the specific range of science and technology in function 250 as between the two budgets.

And then we will proceed at that point, assuming that all of that passes, and we know that we are coming out at that $9.1 billion level for function 250. Then we can set about the task of seeing how inventive we can be on any other little cubbyholes or whatnot that we might find, and project for you in the best way possible.

My theories have been that yes, you have got to have the 1-year pop of across-the-board freezes, but thereafter, you have got to continue and provide for growth, particularly in the areas that are critical to the future of the country and its economic competitiveness, which the area of science and technology is so important.

And thus, you know where I am going now. I found out that when I went back to the Budget Committee and the Democratic Caucus and made that argument to get up $300 million back to the previous level, that they bought it on that basis, and so we have got at least some first glints of the sunshine with regard to the future of technology budgets, and particularly yours.

Mr. BEGGS. Well, I appreciate that, Mr. Chairman, you know I agree with that completely.

Mr. NELSON. What would you do on the space station?

Mr. BEGGS. Well, we took a cut in that. I would try to keep going through these phase B studies and assess it next year in terms of whether we are in a position to go forward with the hardware program. If the budget constraints were severe enough to where we couldn't see our way clear to go ahead with the hardware program, the work we did would not be lost. We would be able to give a good assessment of what we could do whenever it was decided to start.

I would hope that wouldn't happen. I just, as you know, returned from Japan, in which we signed the MOU for technical cooperation with the Japanese. We have signed our agreement with Canada, and I am prepared to sign the agreement with the European Space Agency the week after next. So all of the nations of the world with which we have cooperated technically in the last couple of decades in space have responded very favorably to our invitation. And as I have said a number of times in the past, all of those nations suffer larger deficits as a percentage of GNP and as a percentage of their national budgets than we do. And yet, by our example, we have shown them that this program pays in the long run, and that the investments you put in it pay off. It is one of the primary high-tech programs that the Nation supports that has proven to be a very

good investment over the years. And they have learned by that, so that is the reason they are willing to cooperate.

So I think it would be distressing if, after we invited them and they accepted our invitation, that we would have to say, well, we are going to stretch the program out for several years, and we are not going to begin the hardware phase until some subsequent year when we decide we can afford it.

I could make a longer speech, but I won't.

Mr. NELSON. Well, just to conclude this, and we will get back to Centaur, crunching the numbers that I know of now, I happen to agree with you on that assessment about space stations for the phase B.

And we are going to follow that up the week after next at the European Space Agency headquarters. And I think your team has done a commendable job in getting that international interest.

By the way, we have a memo in this committee that is quite concerned about technology transfer with those other nations.

Mr. BEGGS. Yes, sir, and we are, too, and we are being very careful in that respect, and I might say that they are concerned with technology transfer, too. The Japanese, just a week ago, made that very clear to me, they knew we were worried about technology transfer, and they said, you must remember we are worried about technology transfer, too.

So it is a two-way street, and it is a two-way proposition, and it is going to be those that manage this the best that are going to benefit, I guess. I happen to think that there is still a lot of the old Yankee trader around, and that we can do well if we put our mind to managing that technology issue very well from the beginning, and we are trying to do that.

Mr. NELSON. All right, let's go back to Centaur.

What were the events that led to the sole source procurement of Centaur?

Mr. BEGGS. Well, several things. First of all, General Dynamics San Diego is the division of that company which has handled the Centaur from the beginning. They were supported in that activity by Pratt & Whitney on the RL0 engine, and by Honeywell on the primary—the electronics, and Teledyne on the computer. Those companies supplied that equipment over 20 years. And I might say, we have had a splendid record of reliability and indeed, costs, on the Centaur Program. The vehicles have always been produced in budget, and on time, and the performance record is 98 percent, something like that, or even higher. We can supply that for you, but it is like 98 percent.

When we decided to try to integrate the Centaur and the shuttle back in 1981, we felt that it behooved us not to hold a competition because we felt that the previous experience of all those contractors which formed a team was sufficient that no one could compete with them effectively on the time schedule, and for the quantities of hardware that we were talking about producing, because we are really not talking about something that is going to be produced in very large quantity.

We are talking about something that over the next 10 or 15 years will maybe buy 10 or 15 units. So, with the large investment that we had put in the contractors to produce, and I might add,

with the assumption that we could scale up or scale to a different diameter Centaur in an efficient and straightforward manner, we thought that the contractors we had were the most effective and efficient, and cost-efficient as well, producers we could find. So, we went with them.

The conclusion at that time on the two configurations, that is, the existing Centaur flying on top of a Titan or an Atlas, and the Centaur in shuttle would be 60-percent common, which is a high degree of commonality.

[The information follows:]

Fifty-five operational Atlas Centaur launches have been conducted since 1962 including 22 interplanetary/scientific missions and 33 geostationary communications satellites. The vehicle performance of 49 successes approximates 90 percent. In addition to the 55 operational Atlas/Centaur launches, eight development launches were conducted, of which, five were successful.

So, it was all those reasons that——

Mr. NELSON. That was 60-percent commonality?

Mr. BEGGS. Yes, sir, 60-percent commonality.

Mr. NELSON. From the configuration of Centaur before to the new configuration.

Mr. BEGGS. From the configuration that flew on top of Atlas and Titan——

Mr. NELSON. Is that both D and D-Prime?

Mr. BEGGS. That is both types, yes, sir.

Mr. NELSON. Or was it G?

Mr. BEGGS. G and G-Prime.

Mr. NELSON. I get my alphabet confused.

Mr. BEGGS. The engine is essentially the same—the structure, except for the fact it is larger diameter, the various internal structural parts are very similar, and as I mentioned earlier, we kept the avionics the same, except for those pieces and parts that we could not buy simply because they had gone out of production totally, and the result was a high degree of commonality, and there wasn't much hope of generating much competition. And, a competition would have cost us probably 1½ years to 2 years.

Mr. NELSON. Looking back in that timeframe, was competitive versus sole source a real part of the deliberation at the time?

Mr. BEGGS. Yes. We considered it so.

Mr. NELSON. All right, now, you know what is being talked——

Mr. BEGGS. Since I have come back to this agency, we always look at competition, as my friend here can tell you, in every new procurement we make. We don't always compete it. But we always look at it.

Mr. NELSON. You know, we are reading a lot today about cost overruns in the Defense Department. Are there similarities between Defense and here?

Mr. BEGGS. Well, there are similarities, but there are also differences. There have been a series of articles in the New York Times and the Washington Post which I have read carefully which, in some of the broad claims they make, are right on, and the details are mostly wrong in my experience. But in some of the broad details, they are right, and we have some of the same—we have some of the same vices and commit some of the same sins that they do,

that is, we overspecify in a lot of cases; we sometimes overmanage; and many times, we are overly optimistic.

Now, the overoptimism, I don't think you can do anything about. I will be very candid with you. I don't think the Congress, you can stand up here and make speeches and hold hearings and do anything you want. When a young engineer or program manager is trying to sell a program, he is going to be optimistic. And you can haul him up here and rake him over any kind of—through any kind of torture chamber that you want to rake him through, he will be optimistic, because that is his bread and butter, that is what he lives on is that new program that he is going to be optimistic about.

With regard to the other two, I think there are some things that both we and the Congress can do. The overspecifying and those large volumes of documents that we send out to the contractors, are partially a response to the committees for the criticism of the past, for problems that we have had in programs where we have overlooked something or we have allowed somebody to do something that was dumb. And, so, regulations are written in larger and larger volume. I guess this has been cited many times. If you go back 20 years ago, or even 30, the then existing ASPR's, the armed services procurement regulations, which is the same regulation that we use, we just put our own name on it, but we basically use the armed services procurement regulation, now it is a standard that is issued by the Federal Government.

But the ASPR was a bunch of documents that stood about that high off the table, it was three or four volumes. Today, if you look at that procurement regulation, it is a stack that stands about that high off the floor. It has gotten ridiculous. Furthermore, nobody ever reads through them. I mean, I shouldn't admit that, but I will. But they don't.

Mr. NELSON. Why are you all laughing?

Mr. BEGGS. They don't, and so we have gotten to the point, you know, where maybe we ought to move back somewhere towards that original contract with the Wright Brothers, which was written on one side of one sheet of paper. We probably can't get all the way back there, but we can certainly a long ways back from where we are, and I think that part of our problem, is that we are way overspecified for what we are buying. And both the DOD and NASA are guilty of that sin.

With respect to the management, we have been trying to do something about that in this agency. And I think so, as for DOD, I am not as familiar with their programs, but we have putting a lot of emphasis on the issue of productivity and quality in this agency, and we have been inviting our contractors—you know, we are getting into your hair too much, from a micromanagement point of view, tell us when we are asking for too many reports, and they are. In many cases, they are saying, you know, this report is useless or this particular requirement that you have laid on us to manage the program in excruciating detail is not really achieving the results you want. And we can back away on that somewhat. It is going to be hard to back away completely. But we are at least in a posture where the lines up to the top are fairly short.

Andy Stofan can get on the phone and call me very quickly. It is hard for a little guy who is running a small program in the Department of Defense to get up to Cap Weinberger and say, "Cap, I gotta problem with all these things that are being imposed by these multitudinous layers of management control." But I think NASA has an advantage on that, where our lines are fairly short, and we can do something about that, and we are trying to. But we ought to accelerate that, and I think anything that the Congress can do to say look, if anything that we did in the past in imposing on you either legal or other requirements is making you manage in excruciating detail, that is inhibiting the contractor from doing his job, tell us, and we will back away from that. That would be helpful.

Mr. NELSON. Let's talk about the avionics. Are you going to upgrade them?

Mr. BEGGS. We are not. We don't want to. There is a problem which we are going to have to watch and work very hard, which is that many of the components that go in this thing are very old.

We are going to have to make sure that when we replace a component, replace anything in the—either mechanically or electrically in those avionics that what we have got is qualified well, so that we don't do some subsidiary damage or create some extraneous problem to avionics that we don't anticipate. That is easy to do, unfortunately, in this field. But for the near future, we think that the record of reliability and the performance on this vehicle have proven that what we have is quite reliable.

Now, the Air Force has been asking us to look very carefully at that, and quite rightfully so, because of the age of the components we are putting in. They have been asking us to, and we have spent over the last several years, quite an effort in looking carefully at the design and ensuring that we do have acceptable components. But I would urge both on ourselves and on the Air Force that we not redesign the avionics completely. We need to redesign partially to upgrade the current componentry, and let the design stay or stable as we can get it.

The thing that makes—a lot has been written in recent years, since you have allowed me the floor. A lot has been written in recent years about the great reliability of a lot of redundancy. And I have had, in my checkered career, a lot of experience in designing redundancy into electronic circuits. You always end up with some single point failure. And Old Murphy is always there working on you, and inevitably, that redundant design fails in just the place where you have got that single point failure—single point weakness in the design.

We had redundant avionics in the IUS, a splendid system, which was well designed, I might say, and on which a great deal of money was spent, but it didn't prevent us from having an immediate failure on the IUS. And there we were, you know, standing there with both feet firmly planted in midair, we spent a lot of money, we were sure we had something that would work from the very first, and would work very well, and it didn't.

I might say, I had similar problems going back to when we put the F6 into operation. We had splendid redundancy built into the F6, and we lost some airplanes, unfortunately, in the early years,

because of some single point weakenesses in the design we had overlooked.

Some day, somebody is going to come along and he is going to do it exactly right, and it is going to work fine. But it is not a panacea, and if you have an electronic system that has been tested for a long period of time, that works well, stay with it.

Mr. NELSON. Well, since you are considering or would consider a partial upgrade, how is that going to impact the cost overrun?

Mr. MOORE. Well, Mr. Chairman, in our planning to date, we are not planning any upgrades of the Shuttle/Centaur avionics, as Mr. Beggs has said. We have done some studies with the Air Force on it, but we don't have no plans of carrying this any further than some studies at this point in time. So I don't see any impact to the current cost situation that we have got on the shelf. Centaur.

Mr. NELSON. For the record, you were being very generous, Mr. Beggs. You kept referring to we with regard to the single point failure on the IUS, and we might just draw the distinction, that it was an Air Force vehicle.

Mr. BEGGS. Well, it was, but we were involved. Peripherally, it is true, but we were involved.

Mr. NELSON. Let's talk about the performance capabilities of the G and G-Prime. Is it going to be within the specifications in the contract? Performance capabilities?

Mr. MOORE. As far as we know, Mr. Chairman, today, and I will ask Andy or Mr. Ross over here to comment further. We think the requirements, capability requirements, of the G vehicle, which is the shorter version of the vehicle, is going to be within specs, and also the G-Prime vehicle, which is going to be used on our two-planetary vehicles, are going to be in specs.

Mr. NELSON. What about weight margins?

Mr. MOORE. We are in the process now, and I have taken a position in the Shuttle/Centaur Program for a couple of years now that we should hold some margin. In other words, I have got some margin on the shuttle side. The Centaur people are tracking a margin on their side, and the spacecraft people are tracking some margin on their side.

And we have adopted a philosophy of holding onto that margin until we see exactly how we need to divvy up the pie to best meet our mission objectives, and that is what we are all about, is to try to do the best possible missions we can for Galileo and Ulysses. To date, we have some margin on the Shuttle side, the margins, as I understand them today on the Centaur side is tight, relative to the Galileo flight, maybe a negative 42 pounds, as I understand the numbers to date; Ulysses has got a slight positive margin in it. Over the next months, several months, we will sit down and jointly work with the spacecraft people, the upper stage people, and the shuttle people to settle out on the margins, to come out with the best possible missions we can for those two flights.

So, today, I would have to say I am comfortable with the fact that we do still have some margin left in the program, and I am also confident that we are going to be able to do both the Ulysses and the Galileo missions as we set out to do.

Andy, did you want to add anything?

Mr. NELSON. Mr. Stofan, Mr. Ross, anything to add to that?

Mr. Ross. No, I think you said it right, Jess. The issue is to look at system margins, not the individual components margins. And the way we compensate for that is by allowing some 2,400 pounds available volume in Centaur to take on propellants beyond what we are currently assessing things, so that that margin now resides, and the system can be reflected in payload capability by putting propellants on Centaur.

So I am in agreement with Jesse. I think we are all right.

Mr. MOORE. I think one other comment, let me add, Mr. Chairman, and that is, we are at a stage in both the Centaur Flight Program, as well as the spacecraft programs that these birds will launch toward the planetary vehicles, where a high percentage of our hardware is now weighed hardware; in other words, it is hardware we now have in hand.

So we are getting very confident as a function of time about what weights we are really going to see with the Centaur flight program as well as the spacecraft programs, and now is the time to begin looking at where our risks are from a margin standpoint, and allocating those margins out to best achieve our mission objectives, and that is our plan and that is going to be our approach, in terms of achieving these two very important missions that we have to fly within the next year.

Mr. NELSON. Let's get back to cost.

No one really understood there was going to be a cost overrun until you had already passed the halfway mark in the funding profile. Why? How could you go that far without seeing there was going to be the cost overrun?

Mr. BEGGS. Well, OK, maybe we could share the answer to this, Mr. Chairman. We did anticipate some cost overrun, and we had queried General Dynamics about problem areas as early as 1984——

Mr. STOFAN. October 1984.

Mr. BEGGS. October 1984, and they owned up to a small increase at that time. I think it was $16 or $18 million or something of that order.

We were not satisfied with the answers that we got on that. As a matter of fact, I called the GD management. I said:

> I am worried about this program, you have admitted to a small overrun, but I think that you better take a very hard look at the program, because there are some red flags flying on the thing, and it appears to me that there probably are some things buried that people haven't owned up to out in San Diego, and you should do a review.

And they did initiate a close look at the program late in 1984. It was after that look that they came in to Lewis, to Andy, in late January or early February, and they said, "Whoops. We have got a substantial problem on our hands."

And from there on, it was a question of smoking out all of the details of the magnitude of that problem. Now, when you get into it, some of the problems, some of the cost problems, which had been more or less obscured by the overall eagerness to get the program to continue to move, to meet our schedules, but some of the problems of integration, and some of those problems that relate to the business of shuttle structure and the other problems, started to come to light. They had not been clear before.

So, they were, in a sense, things that we should have anticipated, NASA should have anticipated. Others were overruns in our labor and material that they had swept under the rug.

Mr. NELSON. Who had?

Mr. BEGGS. General Dynamics had swept under the rug. There were problems in their subcontractors which they had known about, but they had not owned up to, and there were problems in their own shop. They were overruning their labor budgets in the shop, and they were—I might add, as well, they were overrunning their overhead budgets that they had set for this program.

And they had not owned up to all of those. So those were on them, completely. And then there were a group of problems that I guess were mutual between us, things that we had not yet owned up to, and problems in the design that probably we could have anticipated at an earlier date if we had really dug in a good deal more deeply into the design that they were coming up with, things that have come to light subsequent to that in things like the structure and the dome problem, and what have you, which started to come out as we started in the Defense Program.

Mr. NELSON. Now, those——

Mr. BEGGS. Some of those, however, even if we had dug very deeply, we wouldn't have been able to uncover, because they were cases where we simply could not have performed preliminary tests to get at the problem. What we needed to do was assemble one, and then the problem came to light.

Mr. NELSON. Those things started really coming out in late 1984.

Mr. BEGGS. They started coming out in late 1984, but they did not—the problems of the contractor were not laid on Lewis and subsequently headquarters of NASA until like late January or early February 1985. That is when we really knew the magnitude of the problem.

Mr. NELSON. Well, then, if that was the case, why in the world didn't you all share that with us when you came up here in your authorization hearings in February?

Mr. BEGGS. Well, we should have alerted you. We could not, at that time, have given you the whole dimension of the problem. We should have alerted you to the fact that we had a problem, and I thought we did say we are looking at a problem in the Centaur.

Mr. NELSON. You did. You said $30 to $40 million range.

Mr. BEGGS. My friend here said $30 to $40 million, but if you had asked me, I would have said the same thing, because that is what we thought we had at that time. As we started digging into it, and as GD started to dig into it, they—at that time, it was in that time period that they sent a corporate team out—March 1, according to Jess—they sent a corporate team out to review all of the estimates, and at that time, the magnitude and the scope of the problem starting to become very evident. But, it wasn't until that time that we knew it was a bigger problem in the $30 to $40 million we highlighted before.

Mr. NELSON. Way back, there was the question of Centaur versus IUS, and one of the questions was, if you already answered, if we went with Centaur because it had the reliability, the system had been flown so much and so forth and so on.

Another one was that it could carry about twice the payload to geosync. So my question to you is, back then, when we said that Centaur was going to be half the unit cost of the IUS, while at the same time, having twice the payload performance . . .
same time, having twice the payload performance . . . is that characterization still valid?

Mr. BEGGS. It is still twice the performance of the IUS. The cost comparison, I think, will come very clear, because we are out on the street with the competition for launching the TDRS 4 and 5. And the competitors on that are Centaur, IUS, and I guess the new OSC's TOSS AMS vehicle. So we will get firm bids from each of those contractors. TRW as well. Anyway, we will have firm bids to compare between the IUS and the Centaur as to what their current assessment is of their cost. I still think that based on past experience, one would have to say the Centaur will be cheaper than the IUS, but I don't know how this competition will shape up, and I might change my mind on that.

But based on past experience on the prices that the Air Force has paid for the IUS, and they have bought 10 or 15 of them, so it is a large enough number to get some assessment. Those prices are higher than what we are projecting for the Centaur today, significantly higher.

But who knows? In a head-to-head competition of this type, some strange things sometimes happen.

Mr. MOORE. On the performance, Mr. Chairman, the Centaur can deliver about 10,000 pounds to geo, and the IUS is about 5,000, and the 20-foot version, the G-Prime version can go in excess of 13,000 pounds per geo, so that is kind of the performance comparisons of IUS and Centaur.

Mr. BEGGS. I might add one other comment, Mr. Chairman. Assuming that the Europeans go ahead with round four and five, i we are going to remain competitive, we need that capability, because that is what they are looking to deliver in the early 1990's.

Mr. NELSON. All right.

Centaur integrated support systems. How many redesigns have you had?

Mr. ROSS. We have had two significant redesigns of that, Mr. Chairman.

Mr. NELSON. I can't hear you.

Mr. ROSS. We have had major redesigns of that structure and its systems. The first—let me elaborate. The first came about as an effort to reduce the complexity, primarily of the pneumatic systems on there, which had been initially designed to be dual failure tolerant, and as a consequence of that, just got too complicated, too many components.

There was some question but that the reliability being more compromised by the number of parts than aided by the redundancy. So we went back with the aid of some help from Johnson, went back and reduced the tolerance to failure, but actually probably improved reliability, and reducing the complexity. The second time around was less significant, and it had to do with the update of loads that Mr. Beggs mentioned earlier, and that update in the load cycle was done, it turned out that we had a seven times increase in loads on certain fluid system components and assists, and it was necessary to redesign those components to react those loads.

That all occurred in—the first one occurred in early 1984, and the second one was sort of in the summer of 1984.

Mr. NELSON. Didn't General Dynamics redesign the valve?

Mr. ROSS. The valve that I think you are referring to is from Fairchild, is done under subcontractor to GD, and it was redesigned as a consequence of the loads revision I have spoken of.

Mr. NELSON. Then that is three instead of the two.

Mr. ROSS. No, that is two. That was part of the loads revision.

Mr. NELSON. OK, the information we had from both the contractor and some of your folks is that it was three redesigns.

Mr. ROSS. I can't think of why it would be categorized that way, but I can look into it if you would like, for the record.

Mr. BEGGS. I think that is wrong, Mr. Chairman. Although I think I can maybe explain the discrepancy in the way they explained, I think the—when the loads problem was discovered, they assessed it against the design and overlooked the valves. Maybe we both overlooked the valves.

Mr. STOFAN. Jim, I think can clarify that on the third——

Mr. BEGGS. some period of time after——

Mr. STOFAN [continuing]. The third redesign, it turned out that the loads redesign redesigned a valve and part of the beam, and the pneumatics redesign, so we considered the loads affected two parts, and so it wasn't three redesigns, it was two pieces and the loads redesign, and one in pneumatics.

Mr. BEGGS. That is better.

Mr. NELSON. Could these redesigns have been prevented?

Mr. ROSS. I think what Mr. Beggs said earlier is one of the lessons learned. I think if we had been quick enough to do those loads analysis in their final form sooner, we perhaps could have avoided that second redesign, although, I must point out that the data that required those loads predictions to be updated came from the real flights of orbiter which were going on in parallel with our design activity.

In the first instance, I don't think it could have been prevented. We struck out on a course to comply with all the safety requirements and assist design and discovered, after having gone through that process, that it was better to reduce the complexity, probably could have been prevented if we were in the position we are now, today, with the learning curve. At the time we did it, we were not. So I don't know how else to answer that question.

Mr. MOORE. But we were, Mr. Chairman, also, as Larry indicated, using flight loads data here, we were getting the flights off and plowing that experience back into the design of this thing at this point in time, and I think that is an appropriately prudent thing to do, as we understand the performance of this bird, plow it back into those vehicles that are going to fly on it.

Mr. ROSS. Jesse, if I may add one thought about that. The process that uncovered the complexity issue that resulted in the major pneumatics system redesign. It was done by the book. That occurred at a preliminary design review, which is exactly where we intend to cover those sorts of things. So I think, within that sort of frame of reference, it is probably good engineering management to have identified that problem. We would like to have had it sooner, but it is exactly where we intended to catch that sort of thing.

Mr. NELSON. We need to move on quickly. The manufacturing defect in the dome curvature; was it responsible for the weld failures that produced the hydrogen leak?

Mr. STOFAN. Yes.

Mr. NELSON. Then was that defect not discovered prior to the occurrence of the leak?

Mr. STOFAN. It was the curvature of the forward bulk head, due to some weld shrinkage in the weld fixture, the curvature came out different than a drawing, the way the stress calculations were made, and it was a shrinkage due to the welding process. So the curvature was a little bit different, and therefore, the stresses were higher. When we got in the test, remember, this is a balloon structure, so it is really—it has to be held up with pressure or it just falls down—we got in the test, and we found out what had happened, we went back and looked then in the entire system from scratch to figure out what had happened, and how could it happen. And after a lengthy investigation, finally determined that it was due to the manufacturing process that caused the bulk head to have a little bit different shape than we had anticipated. And that was a very, very subtle type of thing which, without the test, we would not have found it.

Mr. NELSON. So, the manufacturer does conduct the test, the checks for the curvature before—after they are fabricated?

Mr. BEGGS. Mr. Chairman, if I may add, so the record may be clear on this, when he says it is a balloon structure, what he is talking about, this is a pressure-stabilized structure. It is only when you put it under pressure that it takes its final form. But it only after you load it with the pressure, that it will carry, when it is loaded with the cryogens that you get its true shape. So you really can't—that is the problem I alluded to earlier—you really can't—you really have no way of checking it until we get to the point where we are testing the assembly assembled, because it is only after you go inflated, if you will, or put it under pressure, that it takes its final shape. And when it took its final shape, as Andy said, we found that it had some flat spots on the dome, and it is those flat spots which were then under a greater stress level, and they failed.

So you couldn't really anticipate—that is one that you really couldn't anticipate before you got to that point.

Mr. NELSON. OK, we can wrap this whole thing up with this final question. Lessons learned, so that we won't have these kinds of overruns of in the future. And in part, we have been talking about this, the whole thing. So you just want to give a summary for us on that?

Mr. MOORE. Let me say that I think you have heard some of the things that come out of this hearing here this afternoon, Mr. Chairman, from a lessons learned point of view. We are certainly interested in understanding the scope of our programs as we lay them out and conduct those programs. So clearly, we are very much interested in understanding the lessons learned. We have an activity now underway to try to sit down and assess those lessons learned, and you have heard some of them today talking about the loads and so forth that impacted some of the things.

We will be working on lessons learned from this activity over the next month or so, and compile a more formal set of lessons learned from this, so that other programs, as they come downstream, can share from our experiences we have had here in this particular program.

Today, we have not compiled a formal lessons learned package, but we are in the process of doing that.

[The information follows:]

Lessons learned from the STS/Centaur cost growth are being formulated and will be provided in the near future.

Mr. NELSON. Will you send that to us?

Mr. MOORE. Yes, we will send you the lessons learned.

Mr. BEGGS. I would, as I have stated earlier, I would summarize this way, Mr. Chairman: We probably spent too long—we no doubt spent too long in definitizing the contract. That is a lesson that we relearned, if you will. We ought not to do that.

We, no doubt, delayed too long in enforcing GD into a reassessment of their costs. We didn't really do that until we got some inkling that things were running bad, that is when I gave them a call and said, "Hey, fellas, you—something doesn't smell right here, and you better go back and look," and that wasn't until late last year.

We should have done that somewhat earlier in the process, and I think that in a well-run, well-ordered program, we will write that down and try to observe it more in the future. We, again, that is something that we relearn from time to time, is that we don't force our contractors to reassess promptly enough. We have alluded to the loads problem, and I think we could probably have done that in an earlier time frame. It would have been on top of the problem as we should have, as between Lewis and Johnson, probably should have pushed harder on that. And I think that we can probably cite some cases of underestimates and not facing up to reality on the part of both ourselves and the contractor, who was not on top of this program as hard as they have.

They were letting the engineering process—and we were, too—we were watching it. We were letting the engineering process take too long, we knew it was taking too long, we knew that the releases to the shop floor were not being made in a timely fashion. You could see that. But neither we nor they took prompt action to find out why that was so.

And what it was that was going wrong, had we known that, some of the aforementioned problems could have been attacked earlier.

Mr. NELSON. Thank you, gentlemen. Have a good day. The meeting is adjourned.

Mr. BEGGS. Thank you, Mr. Chairman.

[Whereupon, at 4:50 p.m., the subcommittee was adjourned.]

CENTAUR COST, SCHEDULE AND PERFORMANCE REVIEW

THURSDAY, MAY 23, 1985

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, DC.

The subcommittee met, pursuant to notice, at 1:39 p.m., in room 2325, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

STATEMENT OF HON. BILL NELSON, A U.S. REPRESENTATIVE FROM THE STATE OF FLORIDA

Mr. NELSON. The meeting will come to order.

Good afternoon. We are going to complete our 2 days of hearings to review the cost, schedule, and performance status of the Shuttle/Centaur.

On Tuesday, we heard from NASA officials who have been responsible for managing this program. Today, we are going to hear from the principal contractor which is developing and producing the hardware. We welcome Dr. Alan Lovelace, corporate vice president and general manager for the Space Systems Division of General Dynamics. He is accompanied by Martin Winkler who is director of the Shuttle/Centaur Program at General Dynamics.

As with our hearing last Tuesday, our mission today is to continue to explore the reasons for the overrun, this overrun that is continuing to be experienced by the Shuttle/Centaur Program. Then, we want to try to determine what adjustments or changes in the management policies and procedures of NASA as well as the contractor could help prevent the reoccurrence of similar problems on future programs.

So, we appreciate you all being here to help us shed some light on these problems that have occurred.

I just saw Bob Walker on the floor. He is tied up in a meeting. The vote is still in progress, as a matter of fact, so we will submit his statement for the record.

[The prepared opening statement of Mr. Walker follows:]

OPENING STATEMENT FOR
HONORABLE ROBERT S. WALKER
SHUTTLE CENTAUR COST OVERRUN HEARING
MAY 23, 1985

GOOD AFTERNOON, MR. CHAIRMAN. I WOULD LIKE TO JOIN YOU IN EXTENDING A WELCOME TO DR. ALAN LOVELACE, AND TO THANK HIM FOR APPEARING BEFORE THE COMMITTEE TODAY.

OUR PURPOSE IN THESE HEARINGS IS TO DETERMINE WHAT WENT WRONG IN THE SHUTTLE CENTAUR PROGRAM, AND HOW THE COST OVERRUN, WHICH IS CURRENTLY ESTIMATED TO BE ABOUT $110 MILLION, COULD HAVE OCCURED WITHOUT NASA OR THE CONTRACTOR SEEMING TO KNOW ABOUT IT UNTIL THE PROGRAM WAS MORE THAN HALF COMPLETED.

I WOULD LIKE TO MAKE SURE THAT THE RECORD ACCURATELY REFLECTS MY CONCERNS AND THOSE OF THIS COMMITTEE. WE ARE WELL AWARE THAT THE SHUTTLE CENTAUR PROGRAM IS A TECHNICAL SUCCESS. IN FACT, I WOULD LIKE TO COMMEND BOTH NASA AND THE GENERAL DYNAMICS CORPORATION FOR AN OUTSTANDING JOB IN ADAPTING A VERY COMPLEX UNMANNED UPPER STAGE SYSTEM INTO THE PAYLOAD BAY OF THE ORBITER. DESPITE THE FACT THAT ATLAS CENTAUR HAS BEEN ONE OF THE MOST SUCCESSFUL HIGH ENERGY UPPER STAGES, IT HAS BEEN A VERY DEMANDING ENGINEERING UNDERTAKING TO REDESIGN THE SYSTEM TO BE COMPATABLE WITH THE MANNED SHUTTLE ENVIRONMENT.

HOWEVER, WE ARE DEEPLY CONCERNED THAT THIS PROGRAM HAS SEEN

A COST OVERRUN WHICH APPEARS TO BE IN THE NEIGHBORHOOD OF 25%. ACCORDING TO TESTIMONY FROM NASA ADMINISTRATOR JAMES BEGGS BEFORE THIS SUBCOMMITTEE TWO DAYS AGO, THERE WERE SEVERAL REASONS FOR COST INCREASES. AMONG THESE WERE ENGINEERING CHANGES ORDERED BY NASA WHICH APPEAR TO ACCOUNT FOR SOME $35 MILLION IN INCREASES. WE ALSO UNDERSTAND THAT THERE WERE SIGNIFICANTLY MORE PROBLEMS IN INTEGRATING THE CENTAUR INTO THE SHUTTLE THAN HAD BEEN ANTICIPATED BY EITHER NASA OR THE CONTRACTOR.

WE ARE ALSO AWARE THAT A NUMBER OF THE COST INCREASES WERE DRIVEN BY THE ON AGAIN, OFF AGAIN NATURE OF THIS PARTICULAR PROGRAM. IT IS OBVIOUSLY INEFFICIENT TO RUN A PROGRAM WITH STOPS AND STARTS, AND WHEN THERE ARE STRINGENT TIME CONSTRAINTS IMPOSED BY INFLEXIBLE LAUNCH WINDOWS, THOSE PROBLEMS WILL BE AMPLIFIED.

BOTH THE INVESTIGATION CONDUCTED BY THIS SUBCOMMITTEE, AND TESTIMONY FROM ADMINISTRATOR BEGGS HAVE INDICATED THAT GOVERNMENTAL INDECISION, CONTRACTING DELAYS CAUSED BY THE COMPLEX AND SOMETIMES INEFFICIENT PROCESS, SCHEDULE PRESSURES DRIVEN BY SPECIFIC LAUNCH WINDOWS, AND ENGINEERING AND MANAGEMENT BREAKDOWNS WHICH AFFECTED BOTH THE AGENCY AND THE CONTRACTOR HAVE ALL CONTRIBUTED TO THE OVERRUN WE WILL BE DISCUSSING TODAY.

LET ME MAKE IT CLEAR THAT OUR PURPOSE HERE TODAY IS NOT TO POINT THE FINGER OF BLAME, NOR TO ASSESS LIABILITY FOR A FAILED PROGRAM. IN FACT, THE SHUTTLE CENTAUR PROGRAM IS A SUCCESS STORY IN MANY RESPECTS. THE FLIGHT HARDWARE IS WELL ALONG IN THE

CONSTRUCTION PHASE, AND WE FULLY EXPECT THAT THE FLIGHT HARDWARE FOR BOTH GALILEO AND ULYSSES WILL BE SHIPPED TO THE CAPE WELL IN ADVANCE OF THE ORIGINAL SCHEDULE.

THIS COMMITTEE MUST BE CONCERNED, HOWEVER, THAT THIS PROGRAM HAS SUFFERED A SIGNIFICANT COST OVERRUN. IN A TIME WHEN WE ARE FACING MAJOR CUTS IN MANY PROGRAMS, AND ON THE DAY WHEN THE HOUSE IS STRUGGLING TO ADOPT A BUDGET RESOLUTION WHICH HOPEFULLY WILL START TO CONTROL DEFICITS, WE MUST TAKE A CAREFUL LOOK AT THIS PROGRAM TO DETERMINE WHAT WENT WRONG, AND WHY.

OUR EXPECTATION IS THAT THESE HEARINGS WILL PROVIDE A FORUM IN WHICH WE WILL BE ABLE TO EXAMINE THE SHUTTLE CENTAUR PROGRAM AND COME TO UNDERSTAND WHAT THE VARIOUS PROBLEMS WERE. WE ALSO EXPECT THAT WE WILL BE ABLE TO IDENTIFY WAYS IN WHICH WE WILL BE ABLE TO AVOID SIMILAR PROBLEMS IN THE FUTURE.

WE HAVE ALREADY SEEN SOME INDICATIONS THAT NASA WILL ANALYZE THE LESSONS LEARNED FROM THIS PROGRAM AND APPLY THEM TO OTHER PROGRAMS. THAT ALONE JUSTIFIES OUR EFFORTS HERE TODAY. AS LEGISLATORS WE BEAR THE RESPONSIBILITY TO ENSURE THAT THE TAXPAYERS ARE PROTECTED, NOW AND IN THE FUTURE. AS I NOTED AT OUR FIRST HEARING ON THIS TOPIC, THERE IS A QUOTE AT THE ENTRANCE TO OUR NATIONAL ARCHIVES WHICH SAYS, "THOSE WHO DO NOT LEARN FROM THE PAST ARE DOOMED TO REPEAT IT."

Mr. NELSON. Dr. Lovelace.

Dr. LOVELACE. Thank you, Mr. Chairman. We are certainly pleased to be here. I am hopeful that we can continue to help the committee shed light on the status of the Shuttle/Centaur Program.

Mr. Chairman, I have prepared a written statement, and I have also abbreviated that into a brief oral version. I am prepared to use either one of those this afternoon, if you care to have the long version or the short version.

Mr. NELSON. Long version.

Dr. LOVELACE. Yes, sir.

STATEMENT OF DR. ALAN LOVELACE, CORPORATE VICE PRESIDENT AND GENERAL MANAGER, SPACE SYSTEMS DIVISION, GENERAL DYNAMICS CORP.

Dr. LOVELACE. Although it has been several years since I last appeared before this distinguished subcommittee, I would like to say that it has always been an honor for me to appear here, albeit on some occasions for very positive news and on others to discuss existent matters with which we must deal. Mr. Chairman, I look forward to presenting the relevant facts important to the Shuttle/Centaur Program.

As the subcommittee may recall, in May 1981, a decision was made to adapt the Centaur vehicle as a shuttle upper stage to provide the high performance required for high energy earth escape missions such as Galileo and Ulysses. That vehicle, designated Centaur G-prime, also has the capability of placing about 13,000 to 14,000 pounds into geosynchronous orbit, a capability unmatched by any other upper stage.

Initially development activity progressed until November 1981 when the program activity was temporarily restrained and finally halted in December because of an unresolved debate regarding the best manner in which to perform the Galileo and Ulysses which was then, as you may recall, referred to as the International Solar Polar Mission.

In July 1982, the program was re-started with a clear cut mandate to design, develop, test, and build two G-prime Shuttle/Centaur vehicles and their support systems to launch two interplanetary spacecraft, Galileo and Ulysses, during an approximate 20-day launch opportunity in the May 1986 time period. This has been the driving force behind the G-prime program since that point. Please note that although the program was interrupted for 7 months in 1981, the launch dates have not changed and we fully expect to successfully launch both Shuttle/Centaurs on schedule next year.

The initial contract for two G-prime Shuttle/Centaur vehicles was expanded when the DOD added an initial order for two of the shorter Shuttle/Centaur vehicles, designated Centaur G, and their support systems which were for delivery in 1986. These Centaur G vehicles have the capability of placing approximately 10,000 pounds into geosynchronous orbit. The Centaur G vehicle was designed to maximize performance for longer payloads, whereas the

Centaur G-prime vehicle was designed to satisfy the high energy requirements for planetary missions.

A joint NASA-DOD program office was formed at the NASA Lewis Research Center, and long lead authority for the two Centaur G vehicles was received in 1983. A proposal was submitted, negotiated, and finally definitized in April 1984 at which time the two Centaur G vehicles were added to the initial development contract.

Approximately 60 percent commonality exists between the two Centaur versions. The differences are chiefly in the vehicles' structural shape, G-prime being 30 feet long and G being 20 feet long, and the electronics required for secure communications and Shuttle/Centaur peculiar requirements for DOD payloads.

Therefore, by late 1983, two development programs were under procurement in one contract. The schedules for the two versions are roughly separated by 1 year, G-prime preceding G Centaur.

Subsequent to these activities, a follow-on production contract for three more Centaur G vehicles was definitized. Therefore, General Dynamics is now under contract for vehicles SC-1 through SC-7 plus mission integration activity for several more missions.

Let me highlight some significant events. First, the schedule risk for the Centaur G-prime program has always been extremely high. Launching of two satellites with two Centaurs and two different interplanetary spacecraft from two launch pads within a 20-day period is a feat never before accomplished.

Early in the current development program, it became apparent to NASA and General Dynamics that we would be best served by reserving for the launch site activity whatever bank time existed in the program. After careful study, an agreement was reached to revise the program schedules so that SC-1 and SC-2 deliveries to Florida would be fully 2 months earlier than their respective contractual dates. This was done for the best interest of the program but represented a significant challenge for General Dynamics.

Two, since the Shuttle is a manned vehicle, strict safety rules have been placed on all cargo elements that fly in the orbiter. Most broadly stated, these safety rules cause the Centaur and all other orbiter cargo bay users to be dual fault tolerant. That is, any two components in a system may fail, in any way, and yet the basic function of the system must be maintained. This is a stringent requirement, but it is necessary when human life and national assets such as the shuttle orbiter are at stake.

With the safety rules clearly in mind, General Dynamics set out to design the Centaur G-prime and the Centaur integrated support structure which is the reusable airborne support equipment for the Centaur and the principal means for meeting safety requirements and accommodating shuttle integration requirements.

A number of subsystem preliminary design reviews and a system preliminary design review were successfully accomplished through the early summer of 1983. At that time, at the request of NASA headquarters, a senior NASA team was tasked with the review of the design of the CISS, the integrated support structure, specifically as it related to system complexities dictated by safety and in particular abort mode cases which tend to be very demanding and drive the design.

They recommended that the fluid systems on the CISS be modified to be single fault tolerant rather than dual fault tolerant. This dramatically simplified many of the CISS subsystem designs but caused General Dynamics to scrap many existing fluid system and associated structural avionics interface designs.

Third, for the first time in over 20 years, the Convair Division of General Dynamics had a strike. Over 4200 International Association of Machinists personnel went on strike for 2 weeks during early July 1984. Although the strike was quickly settled, the schedule critical Centaur G-prime program was set back approximately 3 to 4 weeks. This has subsequently been made up by the use of extensive overtime.

Fourth, the Centaur G-prime Program was started 4 years prior to the launch with a performance reserve of about 200 pounds. By any standards, this is a very low reserve and would be low for a mature launch vehicle, no less one in development.

As is usual in this line of work, performance eroded to the point where, in the summer of 1983 and again in the spring of 1984, it became marginal. In each instance, an approximate 200 pound improvement, weight reduction improvement, was made in Centaur performance through weight reduction redesign of a large number of components, some of which were already design complete or, in the latter case, fabrication complete.

These redesigns were considered prudent, although costly, at the time. Other options including release of additional shuttle lift commitment from reserves or the lowering of the shuttle parking orbit were properly rejected at that time and reserved for future contingencies.

As previously mentioned, the safety rules for flying in the shuttle are rigorous. So, too, is the process for proving an upper stage vehicle is safe. The shuttle integration and safety verification process has proved to be of far greater magnitude than originally expected. The effect on the program has been greater than the expected cost due to the integration and safety effort itself.

At lease as large has been the cost and schedule impact due to unexpected redesigns. Some of the systems that had been baselined in the program were derived from the years of successful operation of the expendable launch vehicle Atlas/Centaur. These had to be modified to meet the Shuttle manned safety requirements.

Two significant development problems and requirements changes have caused schedule delays and cost growth. The first of these was discovered in the summer of 1984. At that time, it was realized that specifications for the large cryogenic fluid valves in the Centaur propellant dump system did not properly account for externally induced mechanical loads. Also, the loads themselves imposed by the orbiter at the CISS/orbiter interface had substantially increased. This problem is now corrected, but it resulted in a 3-month schedule impact to the valves and the structure that supports the valves. These redesigns and subsequent changes to fabricated hardware adversely and significantly affected the program cost.

The second of these development problems was discovered in early March of this year at the culmination of the major vehicle structural loads test. At this time, cracks in the forward bulkhead of the Centaur were discovered. Investigation determined that the

cracks were caused by higher than anticipated stresses near the top of the bulkhead which, in turn, had been caused by slight bulkhead contour changes associated with weld shrinkage. This situation should have been anticipated and, unfortunately, was not.

After careful consideration and much testing and analysis, NASA and General Dynamics decided on a repair to the test tank and SC-1 and SC-2. The test tank repair has been completed and verification of the design manufacturing process and flight worthiness has been established through rigorous testing. The SC-1 tank is now repaired, and SC-2 will be repaired this June, next month.

This problem resulted in a 2-month schedule impact along with a moderate cost impact. Also, the Centaur G forward bulkhead design is now being modified to avoid any similar problems.

These have been the only two significant development problems in a program which will expend upwards of 4.5 million manhours of engineering labor.

Next, one of the top level specifications for the Shuttle/Centaur Program calls for stringent screening of semiconductor piece parts. Although we have a semiconductor piece part screening requirement for many years on our Atlas/Centaur program, the Shuttle/Centaur requirements were more stringent.

In meeting such requirements, the experience of the aerospace industry is that the semiconductor device manufacturers are generally unwilling to perform the upgrades required by the tight screening requirements in a timely and cost effective manner. This was our experience also, and we were therefore forced to procure unscreened parts from the manufacturers and high grade the parts through our own screening process. We experienced a large fallout from this process which caused us to reorder and rescreen the affected parts. This problem has now been overcome.

Let me speak to the schedule for a moment. The Shuttle/Centaur Development Program is slightly behind its accelerated internal schedule. A number of pertinent points may be of interest to this subcommittee.

One, all major preliminary design reviews and critical design reviews, over 140 in number, are now complete as scheduled for both Centaur G-prime and Centaur G.

Centaur G-prime original design is complete. Centaur G original design is approximately 80 percent complete.

A number of major tests have been successfully completed. These include both the deployment adapter and forward adapter acoustic tests, the rotation systems test, the Structural Qualification Test Program, the Cryogenic Test Program on the liquid hydrogen tank insulation system, and the year-long set of hardware/software tests in our systems integration laboratory. These tests were, for the most part, completed on schedule.

Flight and ground software development is proceeding and supports program needs, and no major problems are anticipated.

Development and manufacturing of ground support equipment and launch control equipment to support the program activity at launch complex 36A in Florida are on schedule and proceeding well.

SC-1 and SC-2, along with their companion CISS-1 and CISS-2 support structures, will be delivered to Florida on a schedule that

supports the accelerated program needs. Our major quality indicators show excellent results and trends.

In summary, Mr. Chairman, we have faced what we consider a normal set of problems for a highly constrained development program with many technical interfaces. To date, we have satisfactorily resolved them all. In the process, we have exceeded our cost targets by approximately 20 percent. While we do not take this lightly, we do take great pride in the accomplishments to date of this extremely challenging program. We still feel confident in successfully flying the Galileo and Ulysses missions next year and look forward to a Shuttle/Centaur program that will be as long in duration and as successful as our Atlas/Centaur program.

I would appreciate the opportunity now to respond to any questions that the subcommittee may wish to put to me.

[The prepared statement of Dr. Lovelace follows:]

STATEMENT OF
DR. ALAN M. LOVELACE
CORPORATE VICE PRESIDENT AND
GENERAL MANAGER
GENERAL DYNAMICS CORPORATION
SPACE SYSTEMS DIVISION

Mr. Chairman and Members of the Subcommittee:

Although it has been several years since I last appeared before this distinguished subcommittee, I would like to say that it has always been an honor for me to appear here albeit on some occasions for very positive news and on others to discuss existent matters with which we must deal. Mr. Chairman, I look forward to presenting relevant facts regarding the current schedule and cost status of the vitally important Centaur/Shuttle program.

BACKGROUND

As the subcommittee may recall, in May 1981 a decision was made to adapt the Centaur vehicle as a Shuttle upper stage to provide the high performance required for high energy Earth escape missions, such as Galileo, Ulysses and Venus Radar Mapper. That vehicle, designated Centaur G-Prime, also has the capability of placing about 14,000 pounds into geostationary orbit, a capability unmatched by any other upper stage. Initial development activity progressed until November 1981 when program activity was temporarily restrained and finally halted in December because of an unresolved debate regarding the best manner in which to perform the Galileo and Ulysses (then referred to as ISPM) missions. In July 1982, the program was re-started with a clear cut mandate to design, develop, test and build two G-Prime Shuttle/Centaur vehicles and their support systems to launch two interplanetary spacecraft, Galileo and Ulysses, during a 20-day launch opportunity in May 1986. This has been the driving force behind the G-Prime program since that point. Please note that although the program was interrupted for seven months in 1981, the launch dates have not changed and we fully expect to successfully launch both Shuttle/Centaurs on schedule next year.

The initial contract for two G-Prime Shuttle/Centaur vehicles was expanded when the DoD added an initial order for two of the shorter Shuttle/Centaur vehicles, designated Centaur G, and their support systems for delivery in 1986. These Centaur G vehicles have the capability of placing approximately 10,000 pounds into geosynchronous orbit. The Centaur G vehicle was designed to maximize performance for longer payloads, whereas the Centaur G-Prime vehicle was designed to satisfy the high energy required for planetary missions. A joint (NASA/DoD) Program Office was formed at NASA/LeRC, and long lead authority for the two Centaur G vehicles was received in 1983. A proposal was submitted, negotiated and finally definitized in April 1984 at which time the two Centaur G vehicles were added to the initial developmental contract. Approximately 60% commonality exists between the two Centaur versions. The differences are chiefly in the vehicle's structural shape, G-Prime being 30 feet long and G being 20 feet long, and the electronics required for secure communication and Shuttle/Centaur peculiar requirements for DoD payloads.

Therefore, by late 1983, two development programs were under procurement in one contract. The schedules for the two versions are separated by about one year, G-Prime preceding G Centaur.

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Subsequent to these activities, a follow-on production contract for three more Centaur G vehicles was definitized. Therefore, General Dynamics is now under contract for vehicles SC-1 through SC-7 plus mission integration activity for several more missions.

SIGNIFICANT EVENTS

1. The schedule risk for the Centaur G-Prime program has always been extremely high. Launching of two Shuttles, with two Centaurs, and two different interplanetary Spacecraft, from two launch pads, within a 20-day period is a feat never before accomplished. Early in the current development program, it became apparent to NASA and General Dynamics that we would be best served by reserving for the launch site activity whatever bank time existed on the program. After careful study, an agreement was reached to revise the program schedules so that the SC-1 and SC-2 deliveries to Florida would be fully two months earlier than their respective contractual dates. This was done for the best interests of the program, but represented a significant challenge for General Dynamics.

2. Since the Shuttle is a manned vehicle, strict safety rules have been placed on all cargo elements that fly in the Orbiter. Most broadly stated, these safety rules cause the Centaur (and all other Orbiter cargo bay users) to be dual fault tolerant. That is, any two components in a system may fail, in any way, and yet the basic function of the system must be maintained. This is a stringent requirement, but is necessary when human life and a national asset such as the Shuttle Orbiter are at stake.

   With the safety rules clearly in mind, General Dynamics set out to design the Centaur G-Prime and the Centaur Integrated Support System (CISS), which is the reusable Airborne Support Equipment for the Centaur and the principal means for meeting safety requirements and accommodating Shuttle integration requirements. A number of subsystem Preliminary Design Reviews and a system Preliminary Design Review were successfully accomplished through the early summer of 1983. At that time, at the request of NASA/HQ, a senior NASA team was tasked with reviewing the design of the CISS, specifically as it related to system complexities dictated by safety and in particular abort mode cases. They recommended that the fluid systems on the CISS be modified to be single failure tolerant rather than dual failure tolerant. This dramatically simplified many of the CISS subsystem designs, but caused General Dynamics to scrap many existing fluid system and associated structural/avionic interface designs.

3. For the first time in over 20 years, the Convair Division of General Dynamics had a strike. Over 4200 International Association of Machinists personnel went on strike for two weeks during early July 1984. Although the strike was quickly settled, the schedule critical Centaur G-Prime program was set back three to four weeks. This has subsequently been made up by the use of extensive overtime.

4. The Centaur G-Prime program was started, four years prior to launch, with a performance reserve of about 200 pounds. By any standards, this is a very low reserve, and would be low for a mature launch vehicle, no less one in development. As is usual in this line of work, performance eroded to the point where, in the summer of 1983 and again in the spring of 1984, it became marginal. In each instance, an approximate 200 pound improvement was made in Centaur performance by weight reduction redesign of a large number of components, some of which were already design complete, or in the latter case, fabrication complete.

These redesigns were considered prudent, although costly, at the time. Other options, including release of additional Shuttle lift commitment from reserves or the lowering of the Shuttle parking orbit, were properly rejected at that time and reserved for future contingencies.

5. As previously mentioned, the safety rules for flying in the Shuttle are rigorous. So too is the process for proving an upper stage vehicle is "SAFE". The Shuttle integration and safety verification process has proved to be of far greater magnitude than originally expected. The effect on the program has been greater than the expected costs due to the integration and safety effort itself. At least as large has been the cost and schedule impact due to unexpected redesigns. Some of the systems that had been baselined into the program were derived from the years of successful operation of the expendable launch vehicle Atlas/Centaur. These had to be modified to meet STS manned safety requirements.

6. Two significant development problems and a requirements change, have caused schedule delays and cost growth. The first of these was discovered in the summer of 1984. At that time it was realized that the specifications for the large cryogenic fluid valves in the Centaur propellant dump system did not properly account for externally induced mechanical loads. Also, the loads themselves, imposed by the Orbiter at the CISS/Orbiter interface, had substantially increased. This problem is now corrected, but resulted in a three month schedule impact to the valves and the structure that supports the valves. These redesigns, and subsequent changes to fabricated hardware, adversely and significantly affected program cost.

The second of these developmental problems was discovered in early March of this year, at the culmination of the major vehicle structural loads test. At this time, cracks in the forward bulkhead of the Centaur were discovered. Investigation determined that the cracks were caused by higher than anticipated stresses near the top of the bulkhead which in turn had been caused by a slight bulkhead contour change associated with weld shrinkage. This situation should have been anticipated and, unfortunately, was not. After careful consideration, and much testing and analysis, NASA and General Dynamics decided on a repair to the test tank and SC-1 and SC-2. The test tank repair has been completed and verification of the design manufacturing process and flight worthiness has been established through rigorous testing. The SC-1 tank is now repaired also and SC-2 will be repaired in June. This problem resulted in a two month schedule impact along with a moderate cost impact. Also, the Centaur G forward bulkhead design is now being modified to avoid any similar problems.

These have been the only two significant developmental problems in a program which will expend upwards of 4.5 million manhours of engineering labor.

7. One of the top level specifications for the Shuttle/Centaur program calls for stringent screening of semiconductor piece parts. Although we have a semiconductor piece part screening requirement for many years on the Atlas/Centaur program, the Shuttle/Centaur requirement was more stringent.

   In meeting such requirements the experience of the aerospace industry is that semiconductor device manufacturers are unwilling to perform the upgrades required by the tight screening requirements in a timely or cost effective manner. This was our experience also. We were, therefore, forced to procure "unscreened" parts from the manufacturers and "high grade" the parts through our own screening process. We experienced a large fallout from this process which caused us to re-order and re-screen the affected parts. This problem has now been overcome.

SCHEDULE

The Shuttle/Centaur development program is slightly behind its accelerated internal schedule. A number of pertinent points may be of interest to this subcommittee.

1. All major Preliminary Design Reviews and Critical Design Reviews (over 140 in number) are now complete as scheduled for both Centaur G-Prime and Centaur G.

2. Centaur G-Prime original design is complete. Centaur G orginal design is 80% complete.

3. A number of major tests have been successfully completed. These include both the Deployment Adapter and Forward Adapter Acoustic Tests, the Rotation System Test, the Structural Qualification Test Program, the Cryogenic Test Program on the liquid hydrogen tank insulation system and the year long set of hardware/software tests in our Systems Integration Laboratory. These tests were, for the most part, completed on schedule.

4. Flight and ground software development is proceeding and supports program needs. No major problems are anticipated.

5. Development and manufacturing of ground support equipment and launch control equipment to support the program activity at Launch Complex 36A in Florida, are on schedule and proceeding well.

6. SC-1 and SC-2, along with CISS-1 and CISS-2, will be delivered to Florida on a schedule that supports the accelerated program needs. Our major quality indicators show excellent results and trends.

SUMMARY

In summary, Mr. Chairman, we have faced what we consider a normal set of problems for a highly constrained development program with many technical interfaces. To date, we have satisfactorily resolved them all. In the process, we have exceeded our cost targets by approximately 20%. While we do not take this lightly, we do take great pride in the accomplishments to date of this extremely challenging program. We still feel confident in successfully flying the Galileo and Ulysses missions next year and look forward to a Shuttle/Centaur program that will be as long in duration, and as successful, as our Atlas/Centaur program.

Mr. Chairman, I appreciate the opportunity that you have provided me to present these views. I will be pleased to respond to any questions you might have. Thank you.

Mr. MONSON [acting chairman]. Dr. Lovelace, we thank you for your testimony. We will turn to Mr. Packard for questions at this time.

Mr. PACKARD. Thank you, Mr. Chairman.

I didn't expect to preempt anyone on the committee. I am a guest of this subcommittee but have a very personal interest, of course, because General Dynamics is building the Shuttle/Centaur in the San Diego area.

There have been a series of concerns and problems which, Dr. Lovelace, you have enumerated in your testimony. What would you do to prevent such problems as future possibilities in contracts like this? What are some of the specific things you would try to avoid replaying the same kinds of problems?

Dr. LOVELACE. Mr. Packard, I was thinking coming to Washington to appear before this subcommittee what lessons had I learned as a result of our experience. I came to the conclusion maybe I should title it lessons learned and re-learned, because sometimes we tend to re-learn things that we have forgotten. Let me share a couple of thoughts with you.

The start-stop activity in the front of this program was very disruptive, and it is, I think, for any very highly technical complex program. Many times, you can't avoid that, but in a program like the Shuttle/Centaur Galileo and Ulysses missions, you have a unique situation in which the requirement to launch on schedule is set by the celestial mechanics. As a consequence of that, as managers, we are normally accustomed to managing dollars and people and the schedule, we really cannot manage the schedule. The only alternative is to delay the launch for approximately 13 months with inordinate costs associated with that.

So, we have been attempting, of course, to manage the costs of the program and the manpower and meet that schedule. Stops and starts in the front end of a program like that tend to give you a high state of concurrency. By that I mean you're designing almost instantaneously. You are putting planning on the floor to manufacture. You are doing your safety reviews concurrently. You are fabricating hardware. If you have any problems in that time period, they are amplified. Their impact on a program is amplified 5- or 10-fold. It is hard to say.

If you would allow me one other observation that I think I found, we underestimated the difficulty of integrating the Centaur into the shuttle and doing it in a very efficient, reliable, and safe way. You understand we were coming off of an experience on Atlas/Centaur in which we had had something like 95 percent operational reliability. We had 30 successful launches, in fact, a system that had launched every interplanetary payload in the free world. Yet, we did underestimate the requirements to insert that Centaur into the manned vehicle called the shuttle.

I can say no more than that I certainly learned a lesson in that regard.

Mr. PACKARD. Wherein do we find the principal causes of cost overruns? I think never before has the concern for cost overruns been more heightened than it is right now. People are wanting to know why and certainly we want to know why. What were the specific causes of cost overruns in this project?

Dr. LOVELACE. Let me outline the elements. We certainly had design changes during the course of the development. We had three major changes, one associated with the loads, one associated with the need to take weight out of the system, a weight reduction redesign. We had one associated with fluids, simplification of the fluid system that I referred to in my statement.

Mr. PACKARD. May I break in and just ask where were these design changes initiated?

Dr. LOVELACE. Let's see, well, let me take the loads one, for example. Half of that was initiated by General Dynamics in the fact that we underestimated the loads. Half were—hard for me to give you quantification of that—was generated by loads passed through from the orbiter. In other words, the more we fly the Shuttle System, the more we understand the environment and we can quantify the environment in the Shuttle payload bay, and it is important to pass those loads through to people who are going to be, if you will, riding, payloads that will be riding in the payload bay.

So, there is an example in which it initiated from two different sources.

The fluid simplification item was probably generated, as I recall, because of a concern on the part of NASA headquarters that maybe we, collectively, people in the field were making the thing too complicated. They wanted a group to come in, and a group of engineers from, I think, principally led by the Johnson Space Center came in, did that review, did simplify it. It was absolutely the right thing to do, but it again came, as I remember, a year to 18 months into the program and we were quite far along in the design.

Mr. PACKARD. Do you anticipate any further design changes?

Dr. LOVELACE. No; I think we will only—my posture right now is that we are only going to make design changes if, in fact, there are any other safety considerations that have to be accommodated or we need to make any changes to actually build the hardware. I don't anticipate any major design changes of the magnitude that I have just outlined.

Mr. PACKARD. Please continue on other methods you feel can or reasons why there were cost overruns.

Dr. LOVELACE. We mentioned extensive use of overtime, and we have used a good deal of overtime in the program, mindful of the schedule that it is a tough schedule, and wanting to get the hardware down to the Cape ahead of contract schedule so that we could discover any other problems down there as soon as possible. That was a contributor.

Let's see. Marty, maybe you have some——

Mr. PACKARD. Let me ask, along with your concern with the overtime, do you anticipate that in order to stay on schedule from this point until launch time that you will continue to require a great deal of overtime and, thus, can we anticipate further cost overruns between now and the completion of the project?

Dr. LOVELACE. We will continue to use extensive overtime.

Mr. PACKARD. Was that plugged into the original cost analysis?

Dr. LOVELACE. Yes, sir. Total cost to complete as we have calculated it makes provisions for that. Maybe we won't have to use as much overtime, but I think it is prudent for us to plan that way

and plan to do it that way. And our estimates to complete contain provisions for that. I do not expect any additional overruns.

Mr. PACKARD. Do you expect that you will be able to complete the project on schedule?

Dr. LOVELACE. Yes, sir. My best knowledge of the program, we will complete it within the budget that is being requested in the time that remains to us.

Mr. PACKARD. I believe in yesterday's testimony, NASA feels that cost overruns will run somewhere near $100 million. Do you feel that is a realistic figure at this point in time?

Dr. LOVELACE. I think that is a realistic figure, Mr. Packard. We completed our estimates and made our recommendations to NASA earlier in the year, and that figure is very close to the figure that we recommended and contains additional reserves to avoid any similar occurrences through the completion of at least the General Dynamics portion of this program. That is a good figure.

Mr. PACKARD. This may be a sensitive question, but things have arisen since yesterday. Will the concerns and the problems that exist now with General Dynamics, will that have any effect upon the completion of this project, in your judgment, in a timely manner?

Dr. LOVELACE. None. I think the management of General Dynamics has been, is, and will continue to be dedicated to seeing the program completed on schedule. We plan to support NASA and these first two interplanetary probes and the Air Force in the follow-on G missions.

Mr. PACKARD. I have been through the facilities. General Dynamics was able to brief me on the development of the Shuttle/Centaur Program that they are building. Obviously, it is of great importance to the area that I serve and represent in terms of jobs and in terms of the economy. I simply perhaps ought to make just one statement, and that is that cost overruns across this country have become a great concern to people and are, in some way, inhibiting our success in being able to keep pace with defense and our space programs. I am certainly hoping that our private sector will recognize that these are areas that are very sensitive now and, hopefully, we can avoid them in the future.

Thank you, Mr. Chairman.

Mr. NELSON. Thank you, Mr. Packard. We appreciate your being here.

I might add to your comments. I think that we are entering a new era of limitation in which, on the question—and this is a Congressman who happens to have some fairly decent credentials on defense—I think this new era of limitation is going to require us, with regard to defense procurement, indeed, procurement for everything, to perhaps put a limit on the increase that a contractor could experience before having to come back to the authorizing committee in Congress, before they would allow that particular limit to be pierced.

I think we are going to have to see in contracting, not only in defense but that is where the problems have been highlighted, we are probably going to have to see competitive bidding required. I think we are probably going to have to see to try to cut down all of the different attitudes about this service having its way and the

other service having its way. I think we are probably going to have to see the hand of the Chairman of the Joint Chiefs strengthened.

In other words, I think we are going to have to start doing things in a new way.

Mr. PACKARD. If the chairman would kindly yield on that, I just would like to certainly associate myself with those remarks and indicate I think the American taxpayers are now reaching a point where they are demanding accountability in terms of procurement and even in R&D which our full committee has a great deal to do with. I think they are justified in expecting that, and I think this committee and this subcommittee are going to have to lead the way in either reviewing the contracting procedures or the bidding procedures and the other procedures to monitor these kinds of projects where we will not have to try to explain nor will the contractors have to explain why there are several hundred million in overruns that were not expected that keep our budget in chaos and also keep the American people very dubious about some of the things we are trying to accomplish which are very good for this country.

Mr. NELSON. Everything that I just said about the Defense Department would apply to an agency such as NASA save for the specific reference to the Chairman of the Joint Chiefs where we talk about interservice rivalries. We can certainly see rivalries within NASA, among centers. Indeed, we see the rivalries on the question of assured access to space between the Air Force and NASA. Now, DOT is getting into the whole thing.

So, everybody ought to know that there is a new wave of thinking that is starting to have itself expressed here on Capitol Hill.

I appreciate the thrust of your questions. I will just wrap up and I will turn over to my other colleagues before I get into a lengthy list of questions, but to follow up on Mr. Packard's question to you with regard to the overall problems that General Dynamics has had and how it might or might not influence this particular problem, I would be a little more specific and ask you whereas General Dynamics had had the specific problems of assigning improper charges against certain defense contracts that has been alleged in some of the hearings here on Capitol Hill, my specific question is, as the program manager for this particular program, have you checked to make sure that no similar problem is going to exist in accounting procedures being used on this Shuttle/Centaur contract?

Dr. LOVELACE. Mr. Chairman, let me answer the question this way. I identify with your comments about the changing environment that we are in. It is clear that it is changing, it should change, and we in General Dynamics are going to be part of that change process. We have already altered our procedures in advance of the more difficult changes that may have to come in cost accounting practices that are currently in use by both NASA and the Department of Defense.

To the best of my knowledge, Mr. Chairman, I have checked with our corporate people. There is no impact, there is no reflection, of any of the alleged improprieties in General Dynamics on this particular contract or overrun.

Mr. NELSON. As corporate vice president and general manager for Space Systems Division, this particular program comes under your responsibility.

Dr. LOVELACE. Yes, sir.

Mr. NELSON. And you are telling us that you are going to make sure there are no improper charges that are assessed against this contract?

Dr. LOVELACE. Yes, sir.

Mr. NELSON. OK. And you said earlier in response to Mr. Packard that you are confident you will make your May 1986 window in Galileo and Ulysses.

Dr. LOVELACE. We are hard down to do that, Mr. Chairman. I have to tell you, though, the schedule has been tight since the beginning of the program, and it is still tight. I think we are going to be there. I think we are going to be there in time to do an orderly and satisfactory job with payload integration, and we are going to do it on schedule to support that launch window.

Mr. NELSON. Mr. Monson.

Mr. MONSON. Thank you, Mr. Chairman.

I appreciate the comments that have been made here today and feel that I should just say one thing, that many of the changes that could, and should be made, have already been outlined to us in various reports that have been made available through the administration or through other sources. And many of those have been generated by the private sector. I think it points out that we in Congress need to do what we can too in hurrying along and making the changes that are required of Congress in order to achieve some of the savings that can result if we will allow for these changes and better management.

To my questions, Dr. Lovelace, it is my understanding that we were at least halfway or more than halfway through this project before we knew that overruns were occurring. Is that a fair statement?

Dr. LOVELACE. I think that is a fair statement, Mr. Monson. I think we were roughly 50 percent expended on the original budget, if you will, when these overrun problems began to surface.

Mr. MONSON. Coming from an accounting background, but not having been in the Federal Government until January of this year, I am not totally familiar with what you may have been required to do under contract or what normal procedures are in NASA, for that matter. But you do come from a large organization that is audited regularly, and I am sure you keep accounting records that meet the accounting standards that are set forth. How is it, then, that if accounting records were being kept, it would be more than halfway through the project before discoveries like this would be made?

Dr. LOVELACE. You are correct, Mr. Monson. We obviously have certified by the Government our accounting systems and practices are certified by the Government so that we have, we believe, reliable and, certainly to the Federal Government's view, reliable data. Let me give you one, I think, major reason why this overrun didn't surface until at least 50 percent of the budget had been expended.

The changes that I referred to earlier in regard to Mr. Packard's question really didn't start until about a year to 18 months after

we were into the program, well along. The consequence of that is that major pieces of the engineering which require a lot of engineering manhours virtually had to be redone. That was the right thing to do, to redo it, but the impact was to continue to have to repeat tasks that were already complete and behind you. You virtually started again.

As a consequence of that, you found that you began to depart from your original budget, because what we normally do, good, I think, business practice, is we give a budget to engineering to do their task, a budget to the operations and manufacturing, and so forth. And engineering began to depart. We began to see, a little past that 50-percent line, in about October 1984, we began to see the divergence of cost data from the budget data that in essence was on the floor.

Mr. MONSON. Were new budgets prepared at the time the changes were made?

Dr. LOVELACE. In some cases, they were, and there was some reserve available to the program manager to, to Mr. Winkler, and he allocated that reserve as we had to deal with additional tasks to be done. Yes, it was done.

Mr. MONSON. And, then, the requirements of the contract for reporting and such to NASA which I assume are there——

Dr. LOVELACE. Oh, yes.

Mr. MONSON. Were being met at all times by your company?

Dr. LOVELACE. Yes; I know of no case in which we did not meet all reporting requirements and on schedule. And those are both technical and financial reports, which I think you may refer to. I think we met all of those requirements.

Mr. MONSON. OK. Thank you.

Mr. NELSON. Mr. Barton.

Mr. BARTON. Thank you, Mr. Chairman.

I would like to echo, Dr. Lovelace, some of the comments that the chairman and other members of this subcommittee have outlined earlier. We are in a situation, even though we are talking about spending approximately $1 trillion—and I don't think any of us can comprehend that—we are getting to a point from the micromanagement situation in the Congress where we are literally wrangling over budget decisions in the hundreds of thousands of dollars. I can give you a real good example.

I represent part of Tarrant County where, as you know, General Dynamics has a production facility. There is an effort with the local officials in Tarrant County to come up with a strike force against dope pushers and drug dealers that are coming into Tarrant County. I am working with Majority Leader Jim Wright and Congressman Armey and the mayors of the various local communities to try to get $150,000, for that. We are just having a real, real battle to get $150,000. It looks like we are going to make it.

And then we come to a situation where, by your own testimony, there is going to be a $100 million cost overrun which should, if I understand correctly, be about 20 percent of the cost. Now, I am an engineer. I am trained as an engineer. Before I was a Member of Congress, I was a cost control consultant for a major oil and gas company. We felt like if we could bring a project in plus or minus 2 percent, sometimes 5 percent, and I am talking Atlantic-Richfield

who has developed the North Slope. We are talking about a big company, but if we were over 2 percent or 5 percent, we had real cost control problems.

I have a little difficulty with a company with the track record of General Dynamics. You put out a fine product. The F-16 is one of the best fighters in the world. I am sure that the Shuttle/Centaur is going to meet its performance requirements. But I am just wondering if there is a real concern, if you realize what $100 million means.

On this committee, I have had arguments with the chairman and my own members about $6 million, $3 million, and yet we are expected to sit here and say, "Yes, you have a tough job and you have some strict engineering requirements and you are doing a good job, so let's go ahead and let you spend the extra money!" We just can't do that anymore.

If you take one thing back to corporate headquarters, take that message back, that this Congress, I think, is not going to be business as usual on the defense budget. It is not going to be doing business as usual in the overall budget. We really are going to hold the General Dynamics of the world to task.

With that in mind, a few questions. Is the Shuttle/Centaur Program the first program of its type that your company has been involved in? Were you involved in the Atlas/Centaur Program earlier?

Dr. LOVELACE. The company certainly was, yes. They did the original design.

Mr. BARTON. So, this is not your first attempt at manufacturing a system of this type. You have had some previous experience.

Dr. LOVELACE. Yes, sir.

Mr. BARTON. So, that even reinforces the fact that the overrun seems to be a little excessive.

The second question I have, again, trained as an engineer, I am familiar with critical path and parts systems, and I would assume that your company also has some sort of a scheduling system like that. Is that correct?

Dr. LOVELACE. That is correct. Yes, sir.

Mr. BARTON. So, given the fact that you are on a tight engineering timeframe, I have read your testimony, I would think that on a critical path system of scheduling, a 2-week strike wouldn't be, even given that is in the critical path, there should be some slack built in so that would not on time delay the project unduly. Am I wrong to feel that way?

Dr. LOVELACE. Let me say, to make sure that I am understanding, obviously, when you lay out a program, you try to build bank time in. This is time that you put into the schedule which is not dedicated yet to doing any particular task but is there in anticipation that you may need some additional time. It is certainly true that we had bank times in the original schedule, and we had to use some of this bank time relative to items like the strike.

Let me remind you, also, that as I indicated in the testimony, we tried to move the delivery schedules up 2 months. We knew that was going to be more of a challenge, but we felt it most prudent to try to leave the bank time, the maximum amount of the bank time, to the end of the schedule when the hardware was arriving at the

Cape and when we were flowing through, integrating the payloads and integrating it into the shuttle.

The consequence of all that is we did not back off on the overtime. You know, I tell you how I felt. I felt I was not going to be very, enjoy very much coming back to NASA in 6 or 8 months and saying, the good news is I got my overtime down; the bad news is I am not going to be there in time to launch.

Mr. BARTON. But I would also expect that in a sophisticated company like General Dynamics, with the record that you have had in the past that you would schedule in approximately 20 or 25 percent overtime. That is a general practice on tight programs.

We have to go vote, so I have one more engineering type question. You mentioned as concern number 4 in your testimony that you had a reserve, a required performance reserve, of only 200 pounds. Is that typical? Wouldn't you normally have a much larger percentage of reserve as far as a weight requirement? That seemed to be cutting it pretty fine, and given the fact that projects get heavier and the requirements get tighter. From an engineering standpoint, I believe it would have been prudent to start out with a little larger performance reserve.

Dr. LOVELACE. Mr. Barton, I couldn't agree with you more. I would have liked to have had another year on the program. I would have liked to have had 500 pounds of reserve on it. I didn't have the choice. I still think it is doable. I think we are about to demonstrate that it can be done. And as I indicated to the chairman, I believe we will be there on schedule with a set of quality hardware that will perform the missions as they are outlined.

Mr. BARTON. One last question, do you perceive that there are going to be any other safety problems? A lot of the delays have been due to the strict safety requirements. Have we got those resolved now?

Dr. LOVELACE. We have, I think, most of the safety issues, if you want to call them that, resolved. What will happen, Mr. Barton, is that we will worry safety right down to the last minute, right down to the last second. The safety people are always there, and at any time, somebody may raise another question which we will have to make an analysis to make sure that we have sufficient margins or that we are sufficiently safe to continue with the mission.

So, that will never go away, and I don't want to lead you to believe that there is a day like next month when somebody says it is safe. Forget about it. That payload will be examined and carefully monitored all the way down to May and June of next year when it is launched.

Mr. BARTON. That is all I have, Mr. Chairman.

Mr. NELSON. OK. We will go vote. I have a number of questions, and I will call on Mr. Smith and Mr. Slaughter if you have questions.

The committee will stand in recess.

[Short recess taken.]

Mr. NELSON. The committee will resume. We will be having another vote in a while, so we want to move right on here.

Dr. Lovelace, I understand that you are getting ready to ship some hardware to the Cape, to KSC, for checkout prior to launch. Now, if during the final processing and checkout procedures, if

during that there were a component or subsystem found to be defective, do you have adequate reserves of repair or replacement parts to substitute for any defective parts that may be found?

Dr. LOVELACE. Mr. Chairman, I think we have done a couple of things to that point. I believe we have a full set of spares that will support the first set of flight hardware when it moves down to the Cape, and we have the ability, under the management engineering and launch services contract that was in negotiation now, the ability to bring to bear any additional engineering expertise that might be needed in real time during that last several months leading up to launch.

Mr. NELSON. So you are saying you have the parts, the components.

Dr. LOVELACE. We believe we do. Yes, sir.

Mr. NELSON. Two days ago, I asked Mr. Beggs these questions, and I want to ask you the same. You have said that the Centaur schedule is very tight. The engineering team at General Dynamics is being challenged by the schedule. You said that and NASA said that.

The question that I asked Mr. Beggs and I want to ask you is, is the engineering effort at General Dynamics required to support the upgraded Titan/Centaur Program? Is that engineering effort at General Dynamics detracted or having any kind of negative impact on the Shuttle/Centaur Program?

Dr. LOVELACE. The answer, Mr. Chairman, is no, although that is, I believe, a fair concern, one in fact which we have paid a good deal of attention to. We have seen no competition between those programs for the critical resource which is the engineering manpower.

The second thing is that the SLVX Centaur or upgraded Titan/Centaur Program has been slow in starting. It is much behind, right now, its original schedule. Thus, if there had even been any competition there, it has been pushed out into the future, and I am sure that the engineering of Centaur G, the design of which is 80 percent complete, will be virtually 100 percent complete before that would become an issue again.

The only other areas are Atlas/Centaur, and that is not a problem. Our commercialization activities are such as not to provide any real competition for resources at all in the Space Systems Division.

Mr. NELSON. So, by your last statement, you are saying that the commercialization of Atlas/Centaur in General Dynamics in no way detracts from Shuttle/Centaur activities.

Dr. LOVELACE. None.

Mr. NELSON. All right. Then, as a followon to that, are there any costs associated with the commercializing and marketing of Atlas/Centaur that are being borne in the Shuttle/Centaur Program?

Dr. LOVELACE. None, and the cost accounting system that we have precludes that. None of the costs associated with the attempt, I think is a fair word to describe, the attempt to commericalize the Atlas/Centaur have been allocated to any Government contract or specifically the Shuttle/Centaur Program.

Mr. NELSON. Let me ask you some questions on performance. Are the performance capabilities of both the G and G-prime vehicles within the specifications laid out in the contract?

Dr. LOVELACE. Let me—I am not sure I remember, Mr. Chairman, exactly what specifications are in the contract, but let me tell you my perception right now. The Ulysses, we have sufficient positive weight margin, performance margin, to in my mind cause that not to be of any concern.

In the case of Galileo, the last set of numbers that I saw said that we were negative approximately 42 or 43 pounds. That deficiency will now have to be taken into a level 1 discussion about the overall systems performance which is really what we are interested in, ultimately, is the mission, not just the Centaur. Centaur has to do its portion of that mission, but we have to get into the level 1 discussions. NASA will have to look at the orbiter performance, the Centaur performance, et cetera. Therein lies the answer to the total mission performance.

Mr. NELSON. If you could supply that for the record in writing with regard to the specifications laid out in the contract.

Dr. LOVELACE. I will do so.

Mr. NELSON. And the same with regard to the weight margins.

Dr. LOVELACE. Yes, sir.

[The information follows:]

The Shuttle/Centaur contract contains no performance commitments nor weight margins. Since the Galileo and Ulysses spacecraft were reasonably mature at the onset of the program the performance issue revolved around the delta velocity or energy the Centaur could provide to accomplish the mission objectives. The early commitments were based on maximizing the scientific return for the missions and contained performance margins of about 200 pounds for each mission. A performance margin greater than zero is required for launch. These margins were not adequate for a deveopment program and drove us to two major redesigns in order to meet the performance goals.

Mr. NELSON. Are you or NASA considering making an upgrade in the avionics system?

Dr. LOVELACE. We have done some preliminary design work on an improved avionics suite for the Centaur but not in conjunction with Shuttle/Centaur. It has been a low level activity in support of Lewis. There is no intention right now, no program right now, to actually do that design and no intention to incorporate that into Shuttle/Centaur. It couldn't be available before 1990 or 1991, anyway, even if we were to go at it full bore.

Mr. NELSON. So, you are not aware of any unresolved avionics problems that could have a negative impact on Shuttle/Centaur?

Dr. LOVELACE. No, I am not. The only thing, major task, remaining for us to complete is the qualification of the avionics units, and that is proceeding and proceeding very well and, I think, principally because we had a very rigorous development test that preceded that, so the designs of those avionics boxes look to me as if they are pretty solid.

Mr. NELSON. You know, it was late 1984 when we first started to get some rumblings that there were going to be some overruns. Suddenly, those surged between late 1984 and 1985. Then, a whole new surge came between now and back in early this year. What are the reasons for these surges of these estimates of overrun in this program?

Dr. LOVELACE. Let me see if I can address that, Mr. Chairman, from——

Mr. NELSON. I guess you have already testified to the reasons for the overruns. What I am really asking is why didn't we understand, why didn't you all understand and convey to us what was the depth of this problem, and why did it say 1984 was one thing and then 1985 was another thing, and now it is a lot different than what we had thought, and what is going to happen next month?

Dr. LOVELACE. Mr. Chairman, let me see if I can answer that, because I believe I do understand the thrust of your question. You are correct that in, if my memory serves me, early October, our cost data that we were plotting began to diverge from our budget to complete line, and it was clear that at that time it seemed to us that we were at least $16, maybe $18 million, higher in our expenditures than we had budgeted. We were enveloped within the reserve, so I guess you could in theory say it wasn't an overrun. But in truth, I think we understood it. Those were indicators. We probably didn't pay enough attention to them at that time.

The best analogy that I can think of, Mr. Nelson, to try to help to understand how one gets into a problem like this, it is like being sick. Each of us has come down with a headache. My first reaction is, I will take an aspirin and forget it. The headache persists, and you say I will take three or four aspirin and see if it goes away.

Pretty soon I am convinced I have something; I am sick. Then, I go to the doctor. Then, starts the diagnosis period. I finally admitted I am sick. I finally went to the doctor. He says, you are right. Your temperature is up. Your white corpuscle count is up. You are sick. He may not still know what the root cause of it is, and, as a consequence, he can't fix it.

I think we had a headache in October. I think by November we knew we were sick. We went to the doctor and we started to diagnose the problem. We called in specialists from Lewis and from our corporate headquarters. It took 60 days or so to diagnose that. We finally, I think, drove it down to the root cause which you need to do in order to ensure that you are not just postponing some more illness.

I think we have done that. I think we understand what it has cost us to fix that. And I believe by so doing, we have reduced the risk of having any additional large overrun.

Now, I have to go back and say one thing. When I got that headache in the beginning, I should have gone to the doctor. That is dumb, but that is what happened.

Mr. NELSON. My response to that is the manifestation of the headache in late 1984 was $16 million. Then, it was up to $60 million in early 1985, and it is $110 million now.

Dr. LOVELACE. Let me say that I think the $67 or so million is the real number. The rest of it, Mr. Chairman, is contingency. It is reserve.

There are two things I wanted to do. One of them, I wanted to find out the magnitude of the overrun and the cause of it, to fix it, and to meet the schedule. The second thing was not to come back up here again, Mr. Chairman, and tell you we have had yet a second overrun.

Mr. NELSON. You say that the real figure is about $60 million and the rest of it is contingency?

Dr. LOVELACE. That is right. Let me make sure that we get the correct numbers for you, Mr. Chairman.

After we had finally conducted what we call this cost to complete exercises and we had had our corporate people in, the Lewis people had looked at that, the overrun itself was of the order of $67 million. We had recommended an additional $20 million reserve to be held by General Dynamics and an additional $13 million to be held by NASA. In truth, I didn't really care who held the reserve except that I thought we ought to hold some reserve. That was the recommendation that we made to Lewis Research Center, and that is only on the General Dynamics development, DDT&E contract that covers the development of the G-prime and G vehicles and the delivery of those four upper stages.

Mr. NELSON. So, that is a $20 million reserve that may not then be part of the overall overrun.

Dr. LOVELACE. That is true.

Mr. NELSON. In other words, we may be talking about a $90 million overrun instead of $110 million overrun.

Dr. LOVELACE. That is correct. You could be talking about a lesser overrun, because we have built some contingencies in, hopefully, as I say, to ensure that we complete the task on schedule and within our commitment to Lewis and, hopefully, NASA's commitment to this committee.

Mr. NELSON. Does that $20 million reserve that you say it may be only a cost overrun of $90 million, does that cover the cost overruns to process and launch the Centaurs at KSC?

Dr. LOVELACE. This is only the development. No; the answer to the question is no. This only covers the DDT&E contract that does the engineering design, development, the first four hardware collections, and then delivers them to the Cape. At the Cape, the management engineering and launch services contract then would normally take over to handle the processing of the upper stages and the payloads at ETR.

Mr. NELSON. So, as we sit here and talk about an overrun of possibly $100 to $110 million, you are saying that that could be in the range of $80 to $90 million if the $20 million reserve is not used. I want to understand what we are talking about.

You see, I have to deal in the world of getting votes from people to support the NASA program. If they say to me, why did you have a $110 million cost overrun on Centaur, am I going to be able to say to them, well, that may be only a $90 million overrun.

Dr. LOVELACE. I think you can. The question is we have to ensure that we deliver on the schedule at lowest cost, and that is with the highest quality, I hasten to assert. That is what we intend to do.

It is a first-time article of a high performance vehicle and, as such, is not without risk which we are trying to recognize. There is still risk left in the program, not as much as there was in the beginning, obviously. I think the problems are going to be small problems and not larger ones.

Mr. NELSON. What are the cost overruns for the KSC part of the contract, the overruns that are compared to the original cost targets of the KSC part of the contract?

Dr. LOVELACE. Mr. Chairman, that contract which is called the MELS contract—I believe that is the contract you are referring to that covers the KSC activities—has not been definitized yet. We have made our proposal to NASA, and they are factfinding that proposal, in fact, right now. So, we have not a contractual basis to compare it to, all right?

However, I do want to tell you that our recommendation to NASA was for an increase in the M&E, the management and engineering portion of that MELS program from our last estimate was done in November 1984 and it was at about $27 million. We raised that to $45 million. We put $21 million worth of contingency in that MELS program. That, I guess I am certain as I sit here, will probably be negotiated down in the process. NASA will, I am sure, be tough negotiators. Part of that really reflects my concern about the first time integration of this payload and wanting to be sure that we can accomplish that, particularly for those first two.

Mr. NELSON. You are saying that the contract definition hasn't been set down in writing yet on the KSC portion?

Dr. LOVELACE. I believe the definition of the work to be done has been fairly described. What we are really doing now is factfinding regarding our estimates, that is to say, General Dynamics' estimates of the manpower required to do that and the reserved necessary in those areas. That is going on right now.

Mr. NELSON. So, we are not talking about $110 million overrun. We are really talking about, on top of that, perhaps another $39 million?

Dr. LOVELACE. I don't believe so, Mr. Chairman, but you are really getting me into an area where I am testifying about some events some of which haven't happened and estimates which are really NASA's province. I believe that NASA had indicated that the overall overrun, including the MELS contract, was of the order of $100 to $110 million. You see, we, General Dynamics, are only a part of that overall series of contracts and associated contracts. I really am not privy to how they arrived at their numbers.

I have to say, we have made conservative input to them. When you look at this witness, you are looking at the person who was principally responsible for putting that conservatism into those numbers because of, frankly, a desire to get the job done and not to be back here, frankly, testifying yet again before this committee about overruns on the Shuttle/Centaur Program.

Mr. NELSON. Earlier you had said that two factors drove the need for massive overtime. You used that as one of the reasons why we are having cost overruns. The two factors were the strike and the three redesigns. Is that correct?

Dr. LOVELACE. I think that is basically correct. I would have to say the latter, that is to say, the redesign activities probably much more dominating than the effects of the strike.

Mr. NELSON. OK. If that is the case, the strike was in July 1984, and the three redesigns, the first one was in the summer of 1983. The next one was the spring of 1984, and the last one was the summer of 1984. Why did those things not show up way until late 1984?

Dr. LOVELACE. I think the reason, Mr. Chairman is that the—let's see how to clarify that—the redesign activity simply meant

that the engineering team that had done the original design, instead of getting off of the task that they had just finished and moving on, stayed on that task because they had to redo the design again. Then, as you collected your cost data, and that obviously follows at some interval behind the actual execution of the task, you began to see the divergence between the budgeted levels and the actual levels.

At that point, it then became necessary to really get in and find out how much more was going to be necessary to complete the task. That is what started the indicated cost study, total indicated cost to complete study, as we call it.

Mr. NELSON. I hear what you say; I am just not sure that I agree with it.

Two days ago, Mr. Beggs said there were several problems that were not owned up to early, were his words, by General Dynamics, problems with subcontractors, growth in labor hours, growth in corporate overhead rates. What is your response to his statement?

Dr. LOVELACE. Mr. Chairman, I, as you of course know, was not present at that hearing. I have heard the comments of the response that Mr. Beggs had made, and I took the liberty of calling Mr. Beggs to see if I could understand myself the source of those comments. I think that it comes back, Mr. Chairman, to the point that what he was saying was that the indicators, which I referred to earlier, those headaches that we saw back in early October, had been ignored. We had not paid attention to those. I believe that was the intention of Mr. Beggs comment or statement.

As he referred it to me, he said neither of us, neither NASA nor General Dynamics really stepped up to those early warnings, those red flags in that early October time period. You can call it sweeping it under the rug, but we chose to ignore the headache. We said it will go away. In the clarity of 20–20 hindsight, that was wrong.

Mr. WALKER. Mr. Chairman, if you would yield——

Mr. NELSON. Mr. Walker.

Mr. WALKER [continuing]. Where does that impact on overhead, however? One of the points made in that testimony is the fact that the overhead costs went up. That is certainly not something that seems to me would gel completely with the statement you just made.

Dr. LOVELACE. I am not, Mr. Walker, I am not sure. Maybe Mr. Winkler has some feeling for the overhead rates, what happened. I know labor rates went up in that time period, but, Marty, do you have any perception of that overhead change?

Mr. WINKLER. What happened, it wasn't corporate overhead rates that increased but the overhead rates at the division which is the so-called wrap-around rate composed of direct labor charges and indirect labor charges. That is put together at a division level. We came down a learning curve on a production program that was a large component of our business base faster than anticipated during 1984. As such, the direct labor hour base in the division shrunk faster than we had anticipated, and the indirect labor base portion of that wasn't cut back fast enough to match that, and that was the source of the overhead increase that Mr. Beggs referred to.

Mr. WALKER. What I hear you saying is that the overhead costs that got charged off to this system that are then going into the cost

escalation that we see are not costs that were directly associated with the Atlas/Centaur Program. Am I hearing wrong? I am hearing that you are charging off divisional costs to something that was not directly related to this program.

Dr. LOVELACE. I think the truth, Mr. Walker, is that the way the cost accounting, the Government cost accounting, system works out there through DCAS established a rate for the division which is based on the production base, direct and indirect labor base for the products and work that is in the division at that time. That becomes the so-called wrap-around rate which is used on all the programs. That is in accordance with the accounting standards that the Government requires.

Mr. WALKER. Well, it may be. And the fact is that I personally have problems with the way we do accounting in the Government, too. But I think what I am hearing you say is that, as this subcommittee with our minds set on this one system, looks at a fairly significant cost escalation, we hear from NASA that one of the problems in that was an escalation in overhead costs. I am now hearing you say that the escalation in overhead cost was only indirectly related to the program that we are directly concerned with. Is that a fair analysis of what I have just heard?

Dr. LOVELACE. I think your statement tends to separate the overhead rate too crisply from Shuttle/Centaur Program. I think the Shuttle/Centaur Program was very much a part of that overhead wrap-around rate calculation. It is not independent. It is not a case of establishing a rate for the Shuttle/Centaur Program that was driven by costs on other programs.

Mr. WALKER. There is a difference here between $39 million and $110 million. You know, I assume that that wrap-around rate was known when we came up with the original cost estimates. Now, if that is the function of the overhead costs that have gone up, I come back to my original question. Why? That wrap-around rate, it seems to me, was incumbent in the first price you gave us.

Dr. LOVELACE. It is, as I understand it, it is a part of the forward pricing calculations that go into the basic contract. I think that was done. I don't know what timeframe those calculations were done.

When you come to the matter of this overrun and going back and doing a total cost to complete, my best recollection of the increases in overhead was that they were about $4.7 million of this total overrun that is under consideration by the subcommittee. It was a function of higher indirect labor costs, and indirect labor costs associated as well with the Shuttle/Centaur Program.

I don't know if that helps you with understanding it.

Mr. WALKER. Well, the trouble is, I think I am understanding it, and what I am hearing is that we ended up with a major cost factor here that may not be directly related to the program, and yet we are faced with trying to explain through NASA or through this subcommittee and so on the fact that we have a $70 million cost overrun. As I say, I think what I am hearing is that at least a portion of that $70 million has nothing to do with the direct costs associated with Atlas/Centaur.

Dr. LOVELACE. I don't come to that same conclusion. I think that overhead increase is directly proportional to the Shuttle/Centaur

Program. It was 7 percent of the total $70 million, as best I recollect it, and it is not, as you interpret what has been said, it is not a charge to the Shuttle/Centaur Program of either direct or indirect manpower that was not applied to that program.

Mr. WALKER. Well, I thought I heard Mr. Winkler say that it was primarily a function of divisional costs that were not necessarily Centaur costs. Is that not what I heard?

Dr. LOVELACE. I don't know that is what Mr. Winkler intended, but I think that the overall division overhead, there are functions of the overall division overhead which are allocated to all programs.

Mr. WALKER. Sure.

Dr. LOVELACE. And those change as the business base changes in the division, and the way we are required to account for those is to roll them up and apply them, on the basis of the contracts, the business, that is in there that is using them. When you do that, Shuttle/Centaur's portion of that was $4.7 million increase.

Mr. NELSON. Let me ask a question——

Mr. WALKER. Well, thank you. I thank you for yielding.

Mr. NELSON [continuing]. No, right on that point. These procedures for overhead are set out by the DCAA.

Dr. LOVELACE. Correct.

Mr. NELSON. Why don't you explain to us a little more about the allocation of those overhead costs. Let's just get that nailed down right here.

Mr. WALKER. That is my problem at this point.

Dr. LOVELACE. I am not sure, Mr. Chairman, what you would like me to address. The whole process of overhead calculation and allocation is certainly——

Mr. NELSON. First of all, you said it is all the contracts within the division. What division are you talking about?

Dr. LOVELACE [continuing]. At the time and right now, this is the Convair Division of General Dynamics.

Mr. NELSON. So, you are not talking about just—well, what other contracts are we talking about that overhead is allocated among every one of them in the Convair division?

Dr. LOVELACE. You have all the major and lesser programs that are part of the Convair business base which includes, just to mention a couple, the Cruise Missile program, the——

Mr. NELSON. Is that including the airplane programs?

Dr. LOVELACE [continuing]. That is handled as a commercial venture. That is handled in the same way that any commercialization of Atlas/Centaur—those, any overhead costs associated with that or sales of those products are not allocatable to the Government, to the base that is applied to the Government contracts.

Mr. NELSON. Since Cruise Missile is a Defense Program, would there every be allocated upon this NASA Program more than its share of the overhead?

Dr. LOVELACE. I would venture to say no, and certainly DCAA and ourselves would be there to prevent that from happening. That is what the system is supposed to—one of the things the system is supposed to do, and I simply do not believe that there is any allocation of overhead to any of these programs that is not a direct benefit to that program.

Mr. NELSON. We are talking about corporate overhead, aren't we?

Dr. LOVELACE. You are talking about, really, talking about division overhead. A part of each of the division's overhead, I guess, contains in it some of the appropriate allocatable costs of the corporate. You know, there are 350 people or so in the corporate office.

Mr. WALKER. What percentage of the total overhead cost does that $4.7 million represent?

Dr. LOVELACE. I don't have that figure with me. In other words, you would like to know what was the basic overhead allocation to which that $4.7 was added?

Mr. WALKER. Yes; what I was trying to figure out is, is that percentage any higher than the percentage of business that the Centaur Program represented?

Dr. LOVELACE. No, I don't know the number. It is several percent. It isn't a large percentage, as you might expect, because the increase was very small as well. I could supply that for the record, Mr. Walker.

Mr. WALKER. What percentage of the business within that division does the Centaur Program represent?

Dr. LOVELACE. Let me think. I would say on the order of 40 or 45 percent.

Mr. WALKER. About 40 to 45 percent of the business within that division. So——

Dr. LOVELACE. That may be a little high. I can check that, but it may be a little bit high.

[The information follows:]

The Shuttle/Centaur Program represented approximately 63 percent of General Dynamics Space Systems Division business in 1984 and approximately 66 percent in 1985.

Mr. WALKER [continuing]. And you don't believe that the $4.7 million is a figure higher than 40 to 45 percent of the divisional overhead expenditures.

Dr. LOVELACE. In other words, if the question is, I don't think there has been an over-allocation of overhead to the Shuttle/Centaur Program, no. I really do not.

Mr. NELSON. Dr. Lovelace, is there a standard Government formula or a standard practice for allocating overhead?

Dr. LOVELACE. Yes.

Mr. NELSON. Were these overhead costs allocated in accordance with that standard?

Dr. LOVELACE. Yes, sir.

Mr. NELSON. What agency establishes that standard practice?

Dr. LOVELACE. Well, it goes back. You are going to tax my memory, Mr. Nelson. I am not an expert on this, but it goes back to the standard accounting practices which, I believe, the Congress initially promulgated and which then have been enforced through the DCAA and which, incidentally, tell you where you allocate overhead, how you do it, and which are audited by the appropriate agencies. All of this is to say that maybe some of that needs to be overhauled, but that is the way it functions today.

Mr. NELSON. You know, earlier, you had a little discussion up here at the table with Mr. Barton and with me and Mr. Packard

about changing the way of business as usual in Washington and how folks are really sort of getting fed up and everything and how people are upset with cost overruns and so forth. So, it may well be that we need to get into that.

For the record, what is DCAA and what is its responsibilities?

Dr. LOVELACE. Defense Contract Audit Agency. They—I am going to get myself into some trouble here defining what their responsibilities are, but they are the principal arm of the Government who come in and audit our contractual activities to ensure that we comply with the standard cost accounting practices that are promulgated. They, in a sense, close that loop. They assure that the kind of concerns that this committee rightfully has about allocation of costs are done in an appropriate manner.

Mr. NELSON. Now, is the allocation of overhead covered in your contract with NASA?

Dr. LOVELACE. I am not sure I—could you repeat the question, Mr. Chairman?

Mr. NELSON. Your contract with NASA, is there a specific line item in there in allocation of overhead?

Dr. LOVELACE. That is an interesting question. I don't think so.

[The information follows:]

The Shuttle/Centaur contract that Convair negotiated with NASA does not contain a specific line item for the allocation of overhead. Overhead costs are identified separately in the cost volume portion of the proposal as a percentage factor to direct labor dollars.

Mr. NELSON. So, if it is not in your specific contract with NASA, then it is covered in that overall procedure under DCAA?

Dr. LOVELACE. Standard practices, and it is audited. That is right, and it is audited to make sure that the costs that are accrued are, in fact, the real costs and are appropriately in the right column. I am not sufficiently a professional accountant to say that is necessarily a good one, but that is the way it has functioned.

Mr. NELSON. I think we had better look at that.

Mr. WALKER. In your conversation with Mr. Beggs that you raised a moment ago, was the issue of the overhead brought up in that conversation and is he satisfied that was properly apportioned?

Dr. LOVELACE. The answer is it did not come up in that conversation, Mr. Walker. In fact, I didn't bring it up. I suffered a little bit from not really having, obviously, a transcript of the hearing yet and not having been present. He did not bring it up at that time, so I really can't answer whether he was satisfied or dissatisfied.

Mr. NELSON. Last Tuesday, Bob, Mr. Beggs had said that one of the problems that General Dynamics had not owned up to early was the growth in the corporate overhead rate. If it is not even a line item in the contract between NASA, as we look into the future and we are having to make NASA leaner and meaner and more efficient, maybe we had better dig into what this DCAA and all of that allocation of corporate overhead and see if something is going on there that oughtn't to be going on.

Mr. WALKER. I think it really raises the question of procedures, because what I find astonishing here is—I mean, I think there is a contract here that called for a certain price for Centaur. Now, it seems to me that contract should have certainly included the over-

head costs anticipated. I am a little at a loss to understand why all of a sudden, then, the overhead costs grew and, in the mind of the NASA Administrator, grew in unanticipated ways and weren't owned up to early on. That, I think, is really a problem. If it is a procedural problem with regard to Government procedure, then we had better get about the business of changing the procedures.

Dr. LOVELACE. Mr. Walker, the overhead costs certainly were contained in the basic contract and were computed for any of the change proposals that went into the contract and to this overrun. To the question is there a specific line item spelled out called overhead, I don't believe so. I think the practices, however, are not unique practices that are being used by NASA in this regard. I think they are standard practices, maybe not good in your professional judgment, but they are the standard practices.

Mr. NELSON. Let me call on Mr. Smith. We just got going here, and I was waiting for you to come back, but I still have a lot to go, so rather than hold you up, please, you proceed.

Mr. SMITH. Well, you have covered a number of areas here that I wanted to get into. At the time, I didn't want to interrupt my colleagues.

Yesterday, Mr. Beggs made a statement. I detected it may have been somewhat tongue in cheek, but I think there was a great deal of seriousness behind it in which he said maybe we ought to go back to the days of the Wright brothers and the 1-page contracts, because the 200-page contracts cost us a lot of money and don't mean anything anyway.

It almost gets to the point where you hear—I don't think there is anything that is more of a problem in terms of perception with the ordinary American citizen than cost overruns. They really don't understand them or if they understand them; they don't understand why they happen. Are we really getting to the point where, because of both the procedures of the Government as well as the procedures of the contractors that we have to say it is impossible to give an honest estimate on a project? Is that where we are?

Dr. LOVELACE. No, sir. I would categorically disagree with your statement of giving an honest estimate. I think we all——

Mr. SMITH. Let me change that to accurate estimate.

Dr. LOVELACE. Ah, accuracy. I think things have, on a very complex program like a Shuttle/Centaur, it is very difficult to give a very accurate estimate because of the technical risks associated with it. I think that is true.

I agree with the chairman's statement and the apparent sentiment that exists among the subcommittee in general here that there is a need to do something about the whole process. I personally tend to concur in that. I think it has gotten overly complex, the process itself. Forget about the complexity of the tasks that we are trying to contract for. The very process of doing business has gotten very complex, and let me say that helps further not to improve the accuracy of estimates because it takes time. The whole process gets longer and longer. Almost by the time you complete it from the time you started, so much time has gone by you have almost automatically induced additional inaccuracies.

Mr. SMITH. But look at the magnitude of the inaccuracies, 200 or 300 percent sometimes. You know, I think a contract, as you know,

is as valid as the enforcement clause and then the two individuals, how willing they are to enforce it. It just seems to me that there is certainly a perception—and I am not blaming it all on your end, believe me, I think there is enough blame to go around, plenty of it on this end.

You essentially deal with two areas, Government initiated overrun problems and corporate initiated overrun problems. But it seems to me that in that contract, we ought to be held accountable, and when I say we I mean Members of Congress, to the taxpayers for whatever areas of overruns occur because we didn't give you the right information or couldn't give you the right information.

On the other hand, why should the taxpayers be stuck for errors, not improprieties in this particular case, but for errors or misjudgments or inaccuracies on your part? What is the sense of having a contract? I mean, you could have a contract to lease a home for $500 a month—you can't find one around here for that, but you can where I live—and if you are not willing to sue somebody for $500, there is no sense in having a contract for the last month.

I don't know whether this is a lack of ability or a lack of desire sometimes to give accurate information in these situations. But I don't see any justification at all for having a contract which allows cost overruns that are industry oriented to be charged to the taxpayers. I don't see any justification for making you responsible for cost overruns that are our fault.

But if you look historically, it seems like the weight is against you, not against us. There may be some disagreement on that, but there is nothing that hits the people in my district, and I am sure I speak for other members, any more difficult. Some person will walk up to you and say, well, you want to take my $50 a month Social Security COLA or you won't give us another $10,000 to clean up a toxic waste dump or whatever it is we need, and yet, as Mr. Barton alluded to earlier, he couldn't get $150,000 for some project to combat drugs in south Texas, and you have a $100 million cost overrun.

Somewhere along the line, and a lot of us have been saying this—I have only been here 4½ months, so I haven't had a chance to say it too long—but somewhere along the line we have to start setting priorities on things around this place. It just doesn't make any sense to me to eat this kind of waste and mismanagement and inefficiency. I would like to hear an explanation for it.

I know we are talking about one project here, the Centaur, and I am getting a little bit off the subject where the chairman and Mr. Walker were, but going back to where the testimony was before. It is a very frustrating thing. I want to go back to it. Is it possible to give an accurate estimate on a project? And if it is not, then why have a contract? Why not just come before this committee and say it is going to cost approximately $1 billion to build such and such or $10 billion to build such and such. We will try to complete it by 1986. We may have to come back here.

The American people would understand that better, a hell of a lot better, than they would if you come and say it is going to cost $1 billion to build this airplane and we are going to have it done in 1986 and instead of having it cost $4 billion and have it done in 1990. That is what is perceived out there. I would like to have some

response to that. I know it is a big mouthful, but I really want to know whether it is possible to give accurate estimates on contracts instead of having 300 percent cost overruns.

Dr. LOVELACE. Mr. Smith, I would give you a response and, hopefully, a brief one that the general subject that you speak to is very much of concern to us in the industry as well. I think we are sympathetic to the view that your constituents have on the matter of overruns. I would say that the practice or the ability to give good estimates, I think we can do that.

I don't know who is the worst at this business of estimating costs. I would be perfectly willing to shoulder that responsibility for the industry's side. We do a poor job, providing you let me leave out the new Senate office building. It is more difficult to estimate high risk items than it is low risk. There is risk in even contracting to build a house and having the contractor come in on cost and deliver.

There is high risk in the kinds of things that some of the agencies that this committee has oversight over, and I speak here in this case of NASA. These are things that have never been done before. You are trying to estimate the cost of doing that and doing it accurately and certainly honestly.

It would be interesting to see some figures on various classes of programs and the magnitude of overruns or the ability of the industry to deliver to the Government their commitments. I haven't seen that data; I am sure it is available.

We have some systems in place that we want competition, first, and people, I think, want to be competitive in their pricing. We have a lot of Government specifications, particularly when it comes to DOD contracts. I frankly believe they are over-specified and may result in not so much overruns but, I believe, in higher costs for some items than really should be paid. And I believe that system is a fair system for reexamination and change.

Mr. SMITH. Let's take the contract at hand, here, the Centaur contract. I am not familiar with the contract process, how it is developed and how long it takes. Is this particular project, for example, how much time did you have at the direction of the Government to prepare your estimates for the construction of the Centaur? And the second question, was it ample?

Dr. LOVELACE. I am not sure I remember how—The time that you are asking, Mr. Smith, would I believe be the time that they came and requested a proposal from us to do this task and we responded to that. I am going to have to ask Marty if he remembers. On the original RFP, request for proposal, how long did we have to respond to that?

Mr. WINKLER. I don't remember exactly, but it is typically in a 3-month time period.

Mr. SMITH. Is that ample time to develop, in your opinion? Do you feel under pressure, under constraints, to get it done?

Mr. WINKLER. I think that is ample time, yes.

Dr. LOVELACE. It depends on who you ask. The people that are doing it would like more time, but I believe that 90 days is sufficient to give a good and accurate estimate. In the case of the Shuttle/Centaur Program, it is not a 300 percent overrun. It is more like 20 percent, and no overrun is reasonable. Absolutely no over-

run is reasonable, but there is higher risk on some programs than others. So, we are not—I take no warm feeling from the sense that we only had a 20 percent overrun.

Mr. SMITH. I have no further questions, Mr. Chairman. Thank you.

Mr. NELSON. Let me ask you, we talked earlier about the task of integrating the Centaur into the space shuttle and that it was grossly underestimated. You all say that you haven't had a lot of experience with this kind of thing, integrating into a manned system. I understand that.

My question to you is what is going on? NASA sure has had a lot of experience in this thing.

Dr. LOVELACE. Well, let me see if I can sort of sort out the elements of the difficulty of that. No. one, I believe you are correct. We have not had any recent experience in integrating into a manned system, General Dynamics, Convair. No. two, I think that we, because we had such a high reliability history with the unmanned Centaur, we may have drawn too much comfort from that unmanned experience as it related to putting that into a manned vehicle. That deluded us into believing that it would be easier to do than it has turned out to be.

Mr. NELSON. It deluded us, too, because that was part of the reason that sold the Centaur as the upper stage.

Dr. LOVELACE. The ease of integrating——

Mr. NELSON. The fact it was so highly reliable and it had been and it was sold to this very committee on the basis that you have a proven system. It works, it works so well, and it has worked in every launch except one over the course of its lifetime. Here, we are talking about a different animal.

Dr. LOVELACE. Mr. Chairman, your original decision, in my view, to see the Centaur integrated to shuttle on the basis of its reliability and record is still correct. It is still correct.

Mr. NELSON. But we didn't account for all of this additional cost.

Dr. LOVELACE. The issue I am talking about is the issue of manned safety of cargo in the payload bay.

Mr. NELSON. Well, I don't fault General Dynamics nearly so much as I do NASA for not being heads up on that, because NASA is the one that had the experience with the manned systems and what it took to integrate there.

Let me go on. We have to move on here. The redesigns, why couldn't any of them have been preventable?

Dr. LOVELACE. Let's look at the redesigns, in no order of importance or chronology. The weight reduction redesigns were done to give us back some positive margin on the performance. I suppose you could have said at that time, don't do that. Let's just try to get more performance out of the rest of the system, the rest of the system being the shuttle orbiter, the main engine, the thrust level of the SSME's, and so forth, the amount of consumables you carry on the mission. You can do a lot of things there.

That early in the program, it is unwise to give away your ready reserve. You need to save that until you get later in the program so that you can do a total systems optimization which is what will be done, of course, in the case of the Galileo and Ulysses missions. So, it was deemed prudent by NASA and ourselves to take some

weight out, so we went in and redesigned parts that, in fact, had been already designed and some parts which had already been fabricated.

The loads issue had two elements to it. One of them, we overlooked an element of the loads model, underestimated it. Second, there was the passthrough of higher loads as we got more shuttle data. Obviously, the reason you get that data is to make sure that you use that in designing the equipments that are going to go into the payload bay. So, it seems imprudent to ignore it. So, we went into that redesign.

The safety redesign, which resulted from, I think, a wise decision on the part of NASA headquarters to send a team down headed up by Johnson Space Center to really look at the fluids system, which is really the complicated safety portion of that system, resulted in a major redesign. Absolutely the right thing to have done. I question if we had not done that our ability to actually get that system qualified and safely through, because it was so complex in that dually redundant mode. So, that redesign, I think, redounded to the credit of the program, both in cost and schedule, despite the fact that it again required us to go back and do a lot of re-engineering.

Mr. NELSON. Let me ask you about the weld failures and hydrogen leaks. Could the test failure have been prevented and the delay been reduced if you had conducted a thorough contour and dimension check of the hardware after it was produced?

Dr. LOVELACE. I think so. Yes, sir. I think our error, as you obviously have deduced by your question, was the fact that we had so much weld shrinkage and the contour of the bulkhead was out of specification, the stress levels higher, and thus we had fatigue cracks. We did not check that after fabrications.

Mr. NELSON. Why are such dimension and contour checks not a standard part of your quality control?

Dr. LOVELACE. That would not be a quality—I don't want to appear to be quibbling technically—but that would normally wouldn't be considered a quality check. It could be considered—what do they call them, Marty—a form check, a mechanical check to make sure it was close to the drawing requirements. We normally have not done that. We do not do that on all of the Centaurs that we have manufactured to date, and we did not do it on this. In retrospect, if we had, we would have recognized right away that the radius of curvature was too low.

Mr. NELSON. Are you going to start doing it in the future?

Dr. LOVELACE. We are going to do it in the future and we will stop doing it only after we have proven that the manufacture processes continue to yield the as-designed product.

Mr. NELSON. Lessons learned, you have talked about them here. Are there any other things that you think should have been done differently?

Dr. LOVELACE. I think not. At the risk of repeating myself, I think not, Mr. Chairman.

Mr. NELSON. Does anybody else have questions?

Mr. WALKER. I have just a couple of questions, Mr. Chairman.

Mr. NELSON. OK. I am going to turn the chair over to you. I am running tight, so if you want to continue this until midnight, it is your pleasure.

Mr. WALKER. I thank you, Mr. Chairman. I assure the witnesses, it won't go that long.

There have been some concerns expressed about the hydrogen leak problem that was caused by the fact that the forward bulkhead in the hydrogen tank was not built to specifications. How did that manage to escape quality control?

Dr. LOVELACE. As I was just saying, in the design of the tank, we are acutely aware of the importance of that radius of curvature angle. What we failed to account for was the fact that the nature of that tank and the number of gores or pieces of metal that had to be brought in there and welded put more thermal energy into that area of the tank and thus caused it to shrink down. So, that, you can say, was the first miscalculation.

The second was we did not check that contour after we manufactured either the test tank or the first two flight articles. Thus, the test tank went into test and discovered the design failure there which was, of course, the purpose of the test, did it in time that we were able to go back and redesign the bulkhead, and one of the flight articles of the test tank has been repaired and tested and the design fix validated, and we have repaired the first flight article, and we will start repairing the second flight article, or have started I guess, yesterday.

Mr. WALKER. One other area, one of the things that we have had a concern about in this committee is the difficulty that you and other contractors have had in getting space qualified electronics components. Do you have any suggestions as to how that problem could be resolved?

Dr. LOVELACE. Mr. Walker, I wish I did, and I guess if I did, there would be a lot of people in the industry who have also been thinking about this and would be very happy about it. The only thing I know to do and is the thing that most of the users do and that is to do an active test of the piece parts as they come in.

We simply are not sufficiently large users, and this is a common problem, sufficiently large users to be able to demand the timely testing on the part of the manufacturer. So, the way the problem generally gets solved is to buy a lot and, at least my term for it is high grade it by running it through a series of active tests that screen out and give you the space qualified piece parts which then go into your avionics. I wish I had a crisp solution for that problem, Mr. Walker.

Mr. WALKER. It is a major concern. I think that we are going to see out over the next several years, as we ask for more and more of those components for bigger and bigger projects, and it is a concern of the committee.

That is all that I have. Staff is jotting down something that has occurred to them.

Would it have made a difference if we had treated Centaur as an extension of the shuttle rather than as a pure payload?

Dr. LOVELACE. I have thought about that. In fact, we have discussed that. I originally thought that it might if we had, in other words, treated it as subsystem to this basic transportation system

and that, as a consequence, we might have stepped up to some of the resolution of some of the safety design tradeoffs earlier. But on the schedule of the Shuttle/Centaur Program, I am not sure that would really have made much, if any, difference.

I have almost come to believe that it probably would not have really alleviated our problem. It might if you had a long serial program with a lot of serial time in it. I fail to see how it might have helped us here.

Mr. WALKER. Thank you.

Mr. Smith, do you have any more questions?

Mr. SMITH. No, thank you.

Mr. WALKER. Can we assume that you would be willing to answer some questions in writing if any other things come up? There were a couple on the minority questions and the majority might have a few.

Dr. LOVELACE. You certainly can, and we will also coordinate to make sure that we have picked up the appropriate questions as we have gone through the hearing, as well, and get the answers to those.

Mr. WALKER. Thank you. One other question, would you mind meeting with staff on some of the proprietary issues after the hearing?

Dr. LOVELACE. No, sir. We would be glad to.

Mr. WALKER. I thank you.

I guess that is it. This hearing is adjourned.

[Whereupon, at 4:11 p.m., the subcommittee recessed, to reconvene subject to the call of the Chair.]

[Additional information submitted for the record by Dr. Lovelace follows:]

GENERAL DYNAMICS
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3 June 1985

The Honorable Bill Nelson
Chairman
Subcommittee on Space Science and Applications
United States House of Representatives
Committee on Science and Technology
2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Nelson:

I am concerned that I may have inadequately addressed some of the questions directed to me last week about the financial status of the Shuttle/Centaur program. As I stated at the time, I am not technically proficient in the field of finance. Thus, my layman's treatment of the subject may not have provided the outstanding quality answer that I would prefer to give and you deserve to receive. Following last week's meeting, I began immediately to prepare a more complete treatment of the subject, which I am pleased now to forward to you.

Your questions concerned three prinicple issues: 1) How does Space Systems Division (nee Convair Division) establish the overhead rates it used in projections and billings? 2) What is the specific impact of division overhead on the Shuttle/Centaur cost overrun? 3) How does Space Systems Division ensure that the Government does not pay for unallowable costs?

Briefly, the answers are simple and straightforward. Space Systems Division establishes its overhead rates through a planning process that is audited by the Defense Contract Audit Agency (DCAA) and thoroughly reviewed and approved by the Defense Contract Administration Service (DCAS). Division management identifies manpower requirements, facilities and other costs (i.e., computers, supplies, travel, etc.) required to support direct contract activities in detail. Departments within the division, namely operations, engineering, quality assurance, finance, etc. are responsible for the preparation of detailed, timephased overhead cost projections which are reviewed and approved by the division controller and the division general manager. This process usually takes four months and involves several iterations in response to issues raised by Convair management, DCAS, and DCAA.

GENERAL DYNAMICS
Space Systems Division

My discussion of the unfavorable rate variance projected at completion of the Shuttle/Centaur contract may have left the impression that I was speaking of an overhead variance. Overhead is only one part of that variance.

$(2.9) million	New Business Funds over Ceiling rate variance
1.0 million	Direct Labor and Fringe rate variance
(2.8) million	Overhead rate variance
$(4.7) million	Total projected rate variance

It is important to recognize that the $2.9 million of New Business Funds over ceiling is not an allowable cost to the Shuttle/Centaur contract and will not be billed to the government.

The overhead rate variance of $2.8 million is primarily due to differences in the accounting treatment of wage increases since the Shuttle/Centaur contract was negotiated. Recently negotiated union wage increases took the form of Lump Sum Wage Payments. These have been treated as overhead cost rather than direct labor cost.

Convair Division withholds a portion of cost incurred from billing as a provision for unallowable costs. For practicality, we have established what we believe is a generous withholding rate to ensure that the government is not currently reimbursing Space Systems Division for any unallowable cost. I am confident that the amounts currently withheld from Space Systems Division billings more than cover any possible amount of unallowable costs which may be identified in the future.

I appreciate this opportunity to clarify my former comments.

Sincerely,

A. M. Lovelace

Alan M. Lovelace
General Manager
Space Systems Division
General Dynamics Corporation